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(Reaffirmed 2006)

Indian Standard

SAFETY REQUIREMENTS FOR ELECTRONIC MEASURING APPARATUS

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INDIAN STANDARDS INSTITUTION
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SAFETY REQUIREMENTS FOR ELECTRONIC MEASURING APPARATUS

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Indian Standard
SAFETY REQUIREMENTS FOR ELECTRONIC MEASURING APPARATUS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 2 June 1981, after the draft finalized by the Electronic Measuring Equipment Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 The object of this standard is:

a) to specify requirements for electronic measuring apparatus so as to ensure reasonable personal protection and protection of the surrounding area against damage;
b) to specify the test methods for showing compliance with these requirements; and
c) to specify the terminology used for dealing with safety matters.

0.2.1 The safety of an apparatus also depends upon matching its design to the installations of the location where it is used. For further explanations (*see* Appendix A).

0.3 Throughout this standard:

a) the term ' apparatus ' is used to cover any apparatus or accessories specified in **1.1**; and
b) the terms voltage and current indicate rms or dc values unless otherwise specified.

0.4 While preparing this standard, assistance has been derived from IEC Pub 348 : ' Safety requirements for electronic measuring apparatus ' issued by International Electrotechnical Commission.

0.5 In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

---

*Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard applies to the following apparatus, whether or not designed for mains supply:

a) electronic measuring apparatus;

b) accessories used with electronic measuring apparatus, including auxiliary apparatus and supply apparatus; and

c) electronic accessories for non-electronic measuring instruments.

1.2 This standard applies to apparatus for indoor use.

NOTE 1 — The conditions for indoor use are specified by the Usage Group 1 of IS : 9176-1979*. These values indicate the conditions of safe operation of apparatus designed and tested in accordance with this standard. Such apparatus may occasionally be subjected to temperatures between +5° and −10°C without degradation of their safety.

NOTE 2 — Requirements for apparatus to be used under the more severe environmental conditions of Usage Group II or III may be dealt with in the future.

NOTE 3 — For apparatus to be used in special areas, such as coal mines or aircraft, as also for drip-proof or splash-proof apparatus, different or additional requirements may apply.

1.3 This standard does not apply to electronic measuring apparatus in medical diagnostic and therapeutic applications. The requirements for such apparatus are contained in IS : 8607 (Part I)-1977†.

1.4 For electronic measuring apparatus used in connection with ionizing radiation, additional requirements may apply.

1.5 This standard may not be appropriate for:

a) some types of direct indicating instruments and some types of recording instruments, or parts of them, containing electronic devices (*see* **3.2**);

b) apparatus designed for a rated supply voltage exceeding:
    i) 480 V (rms) between phases for apparatus for three-phase supply, and
    ii) 250 V (rms) for all other apparatus;

c) electronic apparatus whose measuring function is used exclusively for control purposes.

1.6 This standard is concerned with safety only and not with the other properties of electronic measuring apparatus (*see* **3**).

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*Method for specifying the functional performance of the electronic measuring equipment.

†General and safety requirements for electrical equipment used in medical practice: Part I General.

2. TERMINOLOGY

2.0 The following definitions shall apply for the purpose of this standard.

2.1 Apparatus

2.1.1 *Electronic Measuring Apparatus* — Apparatus which, by means of incorporated electronic devices, serves to measure or to observe quantities, or to supply electrical quantities for measuring purposes.

NOTE — Electronic devices are parts or assemblies of parts which use electron or hole conduction in semiconductors, gases or vacuum.

2.1.2 *Auxiliary Apparatus* — Apparatus which is used for measurement purposes but which is not itself measuring apparatus.

NOTE — Examples; measuring amplifier, frequency divider.

2.1.3 *Supply Apparatus* — Apparatus which takes energy from an electrical supply, in general from the supply mains, and supplies it, in a modified form, to one or more other apparatus.

2.1.4 *Substitute Power Supply* — Supply apparatus which may be used instead of the battery supply of an electronic measuring apparatus.

2.1.5 *Fixed Apparatus* — Apparatus designed to remain permanently fixed to a supporting device, whether or not permanently wired.

2.1.6 *Portable Apparatus* — Apparatus specifically designed to be carried easily by hand and weighing less than about 15 kg.

NOTE — Apparatus designed to be permanently mounted in racks, or apparatus supplied with accessories for permanent mounting are not considered to be portable apparatus.

2.2 Parts and Accessories

2.2.1 *Terminal Device* — A part of the apparatus by which connection is made to external conductors or other apparatus; it may contain several terminal contacts.

2.2.2 *Measuring Earth Terminal* — A terminal directly connected to a point of a measuring or control circuit or to a screening part which is intended to be earthed for measurement purposes.

For other than measuring equipment, this terminal is often termed a ' functional earth terminal '.

2.2.3 *Protective Earth Terminal* — A terminal connected to conductive parts of an apparatus for safety purposes.

This terminal is intended to be connected to an external protective system.

2.2.4 *Thermal Cut-out* — A device which prevents the maintenance of excessively high temperature in certain parts of the apparatus by disconnecting those parts from their supply.

2.2.5 *Safety Switch* — A device which interrupts the supply before access is given to parts which are live.

2.2.6 *Remote Control Device* — A device for controlling an apparatus from a distance.

2.2.7 *Plug-in Unit* — A removable part of an apparatus, connected by plug and socket connection, used to provide for a particular function or type of measurement.

2.3 Electrical Quantities

2.3.1 *Rated Value* — The value (or one of the values) of a quantity which occurs in the designation of the apparatus.

2.3.2 *Measuring Circuit Voltage* — The voltage either across two terminals of a measuring circuit or between one of these terminals and earth.

2.3.3 *Supply Mains* — Any power source which is not used solely to supply equipment consisting of either one apparatus or a combination, for example, in a rack of several apparatus as specified in **1.1**.

2.3.4 *Rated Supply Voltage* — The supply voltage (for three-phase supply, the line-to-line voltage) for which the manufacturer has designed the apparatus.

2.3.5 *Safety Extra-low Voltage* — A voltage which does not exceed 50 V ac rms between conductors, or between any conductor and earth, in circuit which is isolated from the supply mains by means such as a safety isolating transformer or convertor with separate windings.

NOTE 1 — The dc value is under consideration.

NOTE 2 — The voltage limits should not be exceeded either at full load or no load, but it is assumed that any transformer or convertor will be operated at its rated supply voltage.

2.3.6 *Nominal Circuit Voltage* (*Circuit Insulation Voltage*) — The highest voltage with respect to earth which may be applied to a circuit(s) of the instrument so that the instrument is unlikely to become dangerous to touch.

This is the voltage for which the instrument has been constructed from the point of view of insulation.

2.3.7 *Substantially Sinusoidal Waveform* — A waveform with a distortion factor not exceeding 5 percent.

2.4 Constructional Terms

2.4.1 *Clearance* — The shortest distance, measured in air, between conductive parts.

2.4.2 *Creepage Distance* — The shortest distance, measured over the surface of insulation, between conductive parts.

2.4.3 *By Hand* — Denotes that an operation does not require the use of a tool, coin or any other object.

2.5 Tests

2.5.1 *Type Tests* — Tests carried out to prove conformity with the requirements of this standard. These are intended to prove the general qualities and design of a given type of apparatus.

2.5.2 *Acceptance Tests* — Tests carried out on samples taken from a lot for the purpose of acceptance of the lot.

2.5.3 *Routine Tests* — Tests carried out on each item to check the essential requirements which are likely to vary during production.

2.6 Safety Terms

2.6.1 *Accessible Part* — A part which can be touched by a standard test finger (*see* **9.1**).

NOTE — Any accessible area of a non-conducting part is considered as being covered with a conductive layer [*see* **9.5.4** (a)].

2.6.2 *Live Part* — A part, contact with which may cause a significant electric shock.

2.6.3 *Part Directly Connected to the Supply Mains* — A part of an apparatus which is in electrical connection with the supply mains in such a way that a current equal to or greater than 9 A would flow through a connection if it were made between the part and either pole of the supply mains, while the apparatus is not connected to earth.

A current of 9 A is chosen as the minimum rupturing current of a 6 A fuse.

In tests to determine which parts are directly connected to the supply mains, fuses in the apparatus are not short-circuited. Therefore, if a part is connected to the supply mains through an incorporated fuse having a rating of 6 A or less, then that part is not considered to be directly connected to the supply mains.

2.6.4 *Conductively Connected Parts*

2.6.4.1 *Part conductively connected to the supply mains* — A part of an apparatus is considered to be conductively connected to the supply mains if a current greater than 0·3 mA (peak) flows in a resistor of 2 kΩ when such a resistor is connected between that part and any one supply circuit terminal, while the apparatus is not connected to earth.

2.6.4.2 *Part conductively connected to a measuring or control circuit* — A part of an apparatus is considered to be conductively connected to a measuring or control circuit if a current greater than 0·3 mA (peak) flows in a resistor of 2 k Ω when such a resistor is connected between that part and any one measuring or control circuit terminal, while the apparatus is not connected to earth.

Equality of potential of the earth points of a measuring or control circuit and the part under investigation is not deemed sufficient to establish conductive connection for the purpose of this definition.

2.6.5 *Functional Insulation* — Insulation necessary for the proper functioning of equipment and for basic protection against electric shock.

2.6.6 *Supplementary Insulation* (*Protective Insulation*) — Independent insulation provided in addition to the functional insulation in order to ensure protection against electric shock in the case of failure of the functional insulation.

2.6.7 *Double Insulation* — Insulation comprising both functional insulation and supplementary insulation.

2.6.8 *Reinforced Insulation* — Improved functional insulation with mechanical and electrical qualities providing the same degree of protection against electric shock as double insulation.

2.6.9 *Protective Impedance* — Impedance having a value high enough to ensure protection against electric shock under conditions of normal and abnormal use, and having a reliability comparable to that of supplementary insulation or reinforced insulation.

Apparatus with double or reinforced insulation is provided with two safety barriers by its design. For apparatus using protective impedance, the component parts or assemblies concerned are to be tested in respect of their reliability.

2.6.10 *Safety Class I Apparatus* — Apparatus having at least functional insulation throughout and provided with a terminal or contact for protective earthing and, with apparatus designed for mains supply connected by means of a flexible cable or cord, provided with either an appliance inlet with earthing contact or a non-detachable flexible cable or cord with protective earthing conductor and a plug with earthing contact.

2.6.11 *Safety Class II Apparatus* — Apparatus without provision for protective earthing, but with one of the provisions (a) or (b) below:

a) Double insulation and/or reinforced insulation throughout, such apparatus being of one of the following types:

   i) Apparatus having a durable and substantially continuous enclosure of insulating material which envelops all conductive parts, with the exception of small parts, such as name plates, screws and rivets, which are isolated from live parts by insulation at least equivalent to reinforced insulation; such apparatus is called *insulation encased Safety Class II apparatus.*

      The enclosure of insulation-encased Class II apparatus may form a part or the whole of the supplementary or of the reinforced insulation.

   ii) Apparatus having a substantially continuous metal enclosure, in which double insulation is used throughout, except for those parts where reinforced insulation is used, because the application of double insulation is manifestly impracticable; such apparatus is called *metal-encased Safety Class II apparatus.*

   iii) Apparatus which is a combination of types 1 and 2 above.

b) Double and/or reinforced insulation as far as practicable and, where this is not practicable, protective impedance between accessible conductive parts or lightly insulated circuits, and parts of the supply circuit and other live parts which might result in the risk of electric shock in the event of a failure.

   The provision of protective impedance applies only to those types of apparatus whose performance requirements preclude the application of Class I design.

   If apparatus with one of the provisions (a) or (b) above has a terminal or a contact for protective earthing, it is considered to be of Class I construction, even if the design otherwise complies with the principles applicable to Class II apparatus.

2.6.12 *Safety Class III Apparatus* — Apparatus designed for connection to safety extra-low voltage circuits, and having no circuits, either internal or external, which operate at a voltage exceeding the limits of extra-low voltage.

3. GENERAL REQUIREMENTS

3.1 Basic Purpose of This Standard — The apparatus shall be so *designed and constructed as to present no danger, either in normal use or* under fault conditions, providing particularly:

a) personal protection against electric shock;

b) personal protection against the effects of excessive temperature;

c) personal protection against the effects of harmful ionizing and microwave radiation, of liberation of poisonous gases, and of ultrasonic pressure;

d) personal protection against the effects of implosion and explosion; and

e) protection against spread of fire.

In general, compliance is checked by carrying out all the tests indicated under reference test conditions and under fault conditions, as they may occur in practical use and as specified in **4.2** and **4.3**.

As all electronic measuring apparatus are likely to be used in electrically hazardous locations, Safety Class 0 apparatus cannot be deemed to provide sufficient protection and is deprecated in the sense of this standard (*see* **A-1.2** and **A-2.1**).

This standard specifies requirements imposed on the apparatus so as to ensure protection against particular dangers. Attention is drawn to the fact that it will not cover some dangers which might result from the handling of the apparatus, especially not dangers which might arise from the transport of heavy apparatus, defective wall fastenings, fatigue of the operator, etc. However, the apparatus should be designed to protect from, or to reduce, these dangers as far as possible, and the relevant specifications for the protection of workers should be considered.

3.2 Exemptions from This Standard — As a general rule, measuring apparatus containing electronic devices shall comply with this standard.

As an alternative, some types of direct indicating instruments and some types of recording instruments, or parts of them, may at the choice of the manufacturer be designed in accordance with IS : 9249 (Part I)-1979*. provided the choice is clearly stated and in respect of their performance and accuracy, these instruments also comply with the ' Relevant Publications ' specified in the scope of that standard.

This applies to instruments of one of the designs, specified in **3.2.1** to **3.2.3** and to parts specified in **3.2.4**.

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*Safety requirements for indicating and recording electrical measuring instruments and their accessories: Part I Common safety requirements for instruments.

3.2.1 Instruments neither having an incorporated supply source nor needing an external supply source.

The electronic devices of these instruments are energized by the measured quantity, and will in some cases be used for the overload protection of the mechanism.

3.2.2 Instruments having an incorporated supply source, in general a battery, provided the electronic devices are used for processing the indicated or recorded value only, and the voltage of the source, and any voltage generated from that source, does not exceed the limits of extra-low voltage.

An external supply source is allowed when the nominal circuit voltage (circuit insulation voltage) of the measuring circuit does not exceed the limits of extra-low voltage.

3.2.3 Instruments in which the electronic device is used solely to supply an auxiliary voltage, for example, in ohm meters, provided the voltage of the source does not exceed the limits of extra-low voltage. The voltage generated from that source may exceed these limits provided the maximum current output at the measuring terminals is limited to 5 mA ac, 10 mA dc or, for a combined current, 10 mA peak value.

These instruments may have an incorporated supply source or may be fed by an external source.

3.2.4 Those parts of an instrument which do not contain any electronic device and are permanently and substantially separated from the parts which contain electronic devices.

Requirements concerning the separation are contained in IS : 9249 (Part I) - 1979*.

4. GENERAL INDICATIONS REGARDING TESTS

4.1 Conduct of Tests

4.1.1 Tests specified in this standard are type tests, unless indicated otherwise.

Where routine tests are specified, they constitute the minimum requirement.

If this standard requires that tests on components or parts of apparatus are to be made in accordance with their relevant specifications or the like, such tests need not necessarily be performed during the type test of the apparatus laid down in this standard.

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*Safety requirements for indicating and recording electrical measuring instruments and their accessories: Part I Common safety requirements for instruments.

4.1.2 Tests shall be carried out on one and the same apparatus in the order as given in this standard, as far as this is possible.

When dimensions or mass make it impossible to carry out particular tests on a whole apparatus, separate performance of these tests on each of its assemblies is allowed.

4.2 Reference Test Conditions (Reference Conditions for Test Purposes) — Unless specified otherwise, the following conditions shall prevail in the test location [*see* IS : 9000 (Part I) - 1977*]:

a) temperature not outside the range 15 to 35°C,
b) relative humidity not outside the range 45 to 75 percent, and
c) air pressure not outside the range 86 to 106 kPa.

Without hoar-frost, dew, percolating water, rain, solar radiation and the like.

NOTE — The apparatus is expected to remain safe after having been stored or transported under the conditions indicated by the manufacturer. In case of doubt, testing under the present reference test conditions may be useful.

Tests shall be carried out under the most unfavourable combination of the following conditions.

4.2.1 Any position of normal use of the apparatus, normal ventilation not impeded, and the apparatus mounted in accordance with the manufacturer's instructions.

4.2.2 A supply voltage between 0·9 and 1·1 times any rated supply voltage for which the apparatus can be set.

a) Any rated frequency of the supply voltage,
b) For ac/dc apparatus, ac or dc supply, and
c) For apparatus for dc or single-phase supply, line and neutral either connected normally (or at random) or interchanged.

4.2.3 Any voltage, except the supply voltage, between zero and the rated input voltage, if not otherwise indicated by the manufacturer.

For floating inputs and outputs, any potential between zero and the maximum rated floating voltage.

4.2.4 Any position of the controls which are accessible to the user for adjustment by hand, except voltage setting devices complying with **13.8**.

Any remote control device connected or not.

4.2.5 Protective earth terminals connected to earth. Measuring earth terminals connected to earth or not.

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*Basic environmental testing procedures for electronic and electrical items: Part I General.

4.2.6 The apparatus being used for its intended measuring purpose, or not connected for any use whatsoever.

4.2.7 For motor-driven parts of the apparatus, load conditions in accordance with the intended purpose.

When testing motor-driven parts, other parts of the apparatus which are intended to operate at the same time are not disconnected.

4.2.8 In addition, for apparatus supplying electrical quantities for measuring purposes:

a) the apparatus operated in such a way as to provide the rated output power to the rated load impedance; and

b) the rated load impedance of any output circuit connected or not.

4.2.9 In addition, for substitute power supply and apparatus operated together with substitute power supply:

a) substitute power connected to the load specified by the manufacturer or not loaded.

b) substitute power supply having the dimensions specified for a standard battery or an assembly of such batteries is tested in a battery compartment of the most unfavourable design.

c) substitute power supply to be used inside the apparatus is tested within such apparatus, for which it is intended, in accordance with the manufacturer's instructions.

d) substitute power supply connected to the most unfavourable load, including short-circuit.

4.3 Fault Conditions — Testing under fault conditions denotes that, in addition to the reference test conditions mentioned in **4.2**, the breakdown of particular components or insulations is simulated one after the other. Testing under fault conditions is described in **10**.

5. MARKING

5.0 The apparatus shall be marked as follows.

5.1 General

5.1.1 The marking shall be:

a) easily discernible on the apparatus when ready for use, in such a way that there can be no misunderstanding; and

b) indelible and legible.

Compliance is checked by inspection and by the following test.

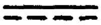
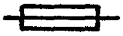
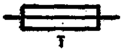
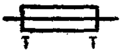
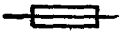
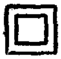
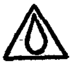
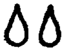
The marking shall not be removed when rubbed lightly with a piece of cloth soaked with either petroleum spirit or water.

5.1.1.1 The information shall preferably be put on the exterior of the apparatus, excluding the bottom. It is, however, permissible to put it in another place that is easily accessible, for example, under the lid or on the exterior of the bottom of a small and light apparatus, provided that location of the marking is given in the instruction manual.

Marking which applies to interior parts only is always placed adjacent to these parts.

5.1.2 When symbols are used, they shall be as follows:

V	volts
A	amperes
Hz	hertz
W	watts
kW	kilo-watts
μF	microfarads
l	litres
kg	kilogrammes
N/cm^2	newtons per square centimetre
Pa	pascals
h	hours
min	minutes
s	seconds
~	alternating current
3 ~	three-phase alternating current
3N ~	three-phase alternating current with neutral

	direct current
	rated current of the appropriate fuse-link
	time-lag D-type fuse-link
	time-lag miniature fuse-link
	long time-lag miniature fuse-link
	class II construction
	(One drop) drip-proof construction
	(One drop in triangle) splash-proof construction
	(Two drop) water-tight construction.

5.1.2.1 Fuse holders shall be marked in accordance with **13.6.2**.

5.1.2.2 Mains-switches shall be marked in accordance with **13.4.1**.

5.1.2.3 Compliance is checked by inspection.

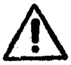
5.2 Identification — The apparatus shall, as a minimum, be identified by:

a) manufacturer's name or registered trade-mark; and
b) model number or name.

5.2.1 Compliance is checked by inspection.

5.3 Warning Symbols

a) If, to preserve the apparatus from damage, it is necessary for the user to refer to the instruction manual, the apparatus shall be marked with the symbol:



The symbol shall be placed adjacent to the device to which it applies.

Marking with this symbol does not exempt the apparatus from any requirement contained in this standard.

b) Apparatus containing radioactive sources shall be marked in accordance with relevant specifications, for example, by the international radiation symbol and the prescribed additional markings.

c) Apparatus containing laser sources shall be marked in accordance with relevant specifications.
Compliance is checked by inspection.

5.4 Mains Supply — The apparatus shall be marked with the following information:

a) Nature of supply:
   - i) ac only: rated mains frequency (or range of frequencies): ~
   - ii) dc only: with the symbol — or ⎓

b) Rated supply voltage (or range of voltages) that can be applied without the adjustment of a voltage setting device.

c) For apparatus having a consumption of 25 VA or more:
   - i) the maximum rated consumption or input current.

   For information purposes, it may be useful:
   - ii) to mark ac apparatus with the symbol ~ ;
   - iii) to mark apparatus suitable for both ac and dc with the symbol ≂ ;
   - iv) to give the maximum consumption or input current if the consumption is less than 25 VA.

c) Apparatus which can be set to different rated supply voltages shall be so constructed that the indication of the voltage to which the apparatus is set is discernible on the apparatus when ready for use. If the apparatus is so constructed that the user can alter the supply voltage setting by hand, the action of changing the setting shall also change the indication.

If the apparatus is provided with more than one voltage setting device, it shall be clear whether all devices shall be set to the same voltage.

d) If there is a socket-outlet to provide power to other equipment, the voltage (if different from the supply voltage) and the power or current which may be drawn.

Compliance with paragraphs (a) to (d) is checked by inspection.

e) If the power consumption is indicated, the actual consumption of the apparatus shall not exceed the marked value by more than 10 percent.

Compliance is checked by a test under reference test conditions, expect that the apparatus is connected to its rated supply voltage.

f) If a substitute power supply is to be used exclusively outside the apparatus, this restriction in use shall be clearly indicated.

Compliance is checked by inspection.

Marking with a symbol is under consideration.

5.5 Terminal and Operating Devices — All terminal and operating devices shall be identified by inscriptions or symbols making clear, if possible, the intended purpose of the terminal or device, and corresponding to the relevant explanation in the instruction manual.

Such inscriptions and symbols may, if necessary for operating devices, also indicate the sequence of operations or the direction of movements to be followed.

The following terminals and devices shall be marked in particular:

a) Earth terminals with the symbol ⏚ .

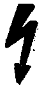
If the use of this symbol for the protective earth terminal is not permitted by a national standard it may be modified, for example, by being placed inside a circle.

The symbol shall be placed adjacent to or on the terminal, but not on removable parts such as screws.

The marking may, depending on national rules, not be required when the protective earth terminal is a part of an approved mains connector.

b) Terminals of measuring and control circuits connected to accessible conductive parts under the provisions of **9.5.9** and whose connection is not self-evident, with the symbol ⊥ .

c) Terminal devices, either input or output, which may be at live voltages exceeding 1 kV shall be marked with the flash shown, thus indicating that connecting to or disconnecting from those devices may be dangerous .



The flash shall be red and shall be placed adjacent to the terminal device.
This is, as an additional warning to the user, a particular application of the symbol since a higher voltage is assigned here to the flash than is generally applicable.

d) The on-position or the off-position of the on/off switch, if any, shall be clearly marked. A signal lamp alone is not deemed to be sufficient.

e) Floating inputs and outputs with their maximum rated floating voltage, if this voltage exceeds the limits of extra-low voltage [*see* **5.5** (c)].

Compliance is checked by inspection.

5.6 Safety Class II Apparatus — shall be marked with the symbol ⧈.

The symbol shall be placed adjacent to, or on the supply information plate.

Apparatus which has only partial additional insulation or which is provided with a protective earth terminal shall not bear this symbol.

Compliance is checked by inspection.

Apparatus of Safety Classes I and III is immediately recognisable by its construction, and carries no safety-class symbol.

6. HAZARDS FROM EMANATIONS

6.0 The apparatus shall be so constructed that personal protection is provided against the effects of ionizing and microwave radiation, of liberation of poisonous gases, and of ultrasonic pressure.

6.1 Ionizing Radiation — The exposure rate at any readily accessible point 5 cm from the outer surface shall not exceed 36 pA/kg under reference test conditions.

Compliance is checked by measuring the amount of radiation. The method of determining the amount of radiation shall be effective in broad and narrow beams and over the range of possible radiation energies.

In general, this applies to apparatus in which electrons are accelerated by voltages exceeding 5 kV.

The requirement does not refer to apparatus containing radioactive substances (*see* **1.1.4**).

The apparatus shall be so constructed that compartments in which electrons are accelerated by voltages exceeding 5 kV cannot be opened by hand.

Compliance is checked by inspection.

6.2 Microwave Radiation — The intensity of microwave radiation at all points in the vicinity of the apparatus shall not exceed 10 W/m^2 under reference test conditions.

This requirement applies to spurious radiation at frequencies between 10 MHz and 100 GHz. It does not apply to parts of the apparatus where microwave radiation is propagated intentionally, for example, at wave guide output ports.

6.3 Poisonous and Injurious Gases — The apparatus shall not liberate dangerous amounts of poisonous or injurious gases under reference test conditions and under fault conditions. Due to the wide variety of such gases, no compliance tests are specified in this standard. A recommended limit for the ozone content of the air surrounding the apparatus is 0·10 ppm (parts per million by volume).

6.4 Ultrasonic Pressure — The ultrasonic pressure at all points in the vicinity of the apparatus likely to be occupied by personnel operating the equipment shall not exceed specified limits under reference test conditions.

A preliminary limit is 110 dB above the reference level of 10^{-12} W/m^2, applicable to frequencies between 20 and 100 kHz. The inclusion of the audible range is under consideration.

Compliance is checked by measuring the pressure.

7. HEATING

7.1 General — The apparatus shall operate safely under normal operating conditions.

The heating shall not cause fire or deformation, and no danger to the operator touching accessible parts.

Compliance is checked by performing the tests prescribed in **7.2** to **7.4**.

For apparatus having special operating conditions, such as short-term or intermittent use, this standard applies as far as compatible with these special operating conditions. A reference to the permissible operating conditions shall then be given by marking the apparatus.

For normal use, no marking is required.

TABLE 1 PERMISSIBLE TEMPERATURE RISES

(*Clause* 7.2)

PARTS OF THE APPARATUS	PERMISSIBLE-TEMPERATURE RISES (°C) TROPICAL CLIMATES	
	Normal Operating Conditions	Fault Conditions
(1)	(2)	(3)
External Parts		
Metal parts knobs, handles, etc,	20	55
enclosure (Note 1)	30	55
Non-metallic parts knobs, handles, etc, (Note 2)	40	55
enclosure (Note 1 and 2)	50	55
Inside of enclosure of wood of insulating materia	50 (Note 3)	80 (Note 3)
Windings (Note 4)		
Wires insulated with non-impregnated silk, cotton, etc	45	65
Wires insulated with impregnated silk cotton, etc	60	90
Oleoresinous enamelled wires	60	125
Wires enamelled with polyvinylformaldehyde or polyurethane resins	75	140
Core Laminations	As for the relevant widing	
Supply Cords and Wiring		
Insulated with ordinary polyvinyl chloride (Note 8)		
not under mechanical stress	50	90
under mechanical stress	35	90
Insulated with natural rubber	35	90
Other Insulations (Note 4, Note 7) *Except Thermoplastic*		
Non-impregnated paper	45	60
Non-impregnated cardboard	50	70
Impregnated cotton, silk, paper and textile, urea resins	60	80
Laminates, bonded with phenol-formaldehyde resins, phenol-formaldehyde mouldings with cellulose fillers	75	100
Phenol-formaldehyde mouldings with mineral fillers	85	120
Laminates bonded with epoxy resins	110	140
Natural rubber	35	90
Thermoplastic materials (Note 5)	(Note 6)	

(*Continued*)

TABLE 1 PERMISSIBLE TEMPERATURE RISES — *Contd*

The values of the temperature rises are based upon a maximum ambient temperature of 350°C for moderate climates and of 45°C for tropical climates, but the measurements are made under normal operating conditions.

NOTE 1 — For areas having no dimension exceeding 5 cm and which are not likely to be touched in normal use, temperature rises up to 65°C (55°C for tropical climates) are allowed under normal operating conditions.

NOTE 2 — If these temperature rises are higher than those allowed by the class of the relevant insulating material, the nature of the material is the governing factor.

NOTE 3 — The permissible tropical rises for the inside of enclosures of insulating material are those indicated for the relevant materials.

NOTE 4 — For the purpose of this standard, the permissible temperature rises are based on the recommendations in IS : 1271-1958*. The materials quoted above are shown only as examples. If materials other than those listed in IS : 1271-1958* are used, the maximum temperatures should not exceed those which have been proved to be satisfactory.

NOTE 5 — Natural and synthetic rubbers are not considered as thermoplastic materials.

NOTE 6 — Due to their wide variety, it is not possible to specify permissible temperature rises for thermoplastic materials. While the matter is under consideration, the following method shall be used:

a) a softening temperature of the material is determined on a separate specimen, under the conditions specified in IS : 2530-1963†, modified as follows:
   i) the depth of penetration is 0·1 mm;
   ii) the total thrust of 10 N is applied before the dial gauge is set to zero or its initial reading noted.

b) the temperature limits to be considered for determining the temperature rises are:
   i) under normal operating conditions, a temperature 10°C lower than the softening temperature as obtained under (a);
   ii) under fault conditions, the softening temperature itself.

NOTE 7 — The table does not apply to materials used in the construction of resistors.

NOTE 8 — The possibility of raising the values for wires and cables insulated with heat resistant polyvinyl chloride is under consideration.

*Classification of insulating materials for electrical machinery and apparatus in relation to their thermal stability in service.

†Methods of test for polyethylene moulding materials and polyethylene compounds.

7.2 Permissible Temperatures — Compliance with the permissible temperature limits is checked by measuring the temperature under reference test conditions when a steady state has been attained.

In general, a steady state is assumed to be attained after 4 h operation.

Temperatures shall be determined for:

- i) windings, by the resistance method; and
- ii) other parts, by any suitable method.

Temperature rises shall not exceed the values given in Table 1.

The values of temperature rises are based upon a maximum ambient temperature of 45°C, but the measurements are made under reference test conditions.

7.3 Preservation of Insulation — Neither the insulation resistance nor the creepage distances and clearances shall be reduced inadmissibly when the apparatus is operated at elevated temperatures.

Compliance is checked under reference test conditions with the exception that the ambient temperature shall be 45°C.

The duration of the test is 4 h, starting from the moment of switching on.

This test is to be carried out only in case of doubt, that is, if the apparatus produces an appreciable amount of heat.

An apparatus which is not designed for continuous operation shall be operated at its specified conditions of operation in such a manner that the greatest possible heating occurs.

After the test, the apparatus shall show no damage in the sense of this standard and shall withstand the tests specified in **9**.

7.4 Mechanical Strength at Elevated Temperatures — The enclosure of the apparatus shall be sufficiently resistant to external forces at elevated temperatures.

Compliance is checked at the maximum temperature attained during the test under **7.3**.

In case of doubt, the rigid test finger of Fig. 1 is applied to different points of the surface with a force of 30 N directed inwards for 10 s each.

The force shall be exerted by the tip of the test finger so as to avoid wedge and lever action.

After the test, the apparatus shall show no damage in the sense of this standard and shall withstand the tests specified in **9**.

8. IMPLOSION AND EXPLOSION

8.1 Implosion — Cathode-ray tubes or other display devices used in apparatus with a maximum face dimension exceeding 16 cm either shall be intrinsically safe with respect to effects of implosion and to mechanical impact, or the enclosure of the apparatus shall provide adequate protection against the effect of an implosion of the tube.

A non-intrinsically safe tube or display device shall be provided with an effective protective screen which cannot be removed by hand; if separate glass screen is used, it shall not be in contact with the surface of the tube or of the display device.

A cathode-ray tube or other display device is considered to be intrinsically safe with respect to the effects of implosion if, when it is correctly mounted, no additional protection is necessary.

For compliance tests, refer to IS : 616-1981*.

8.2 Explosion — When components liable to explode if internally overheated or overcharged are not provided with a pressure release device, protection for the operator shall be incorporated in the apparatus.

It is recommended that pressure release devices be always incorporated so that a discharge will not cause danger to the operating personnel.

9. ELECTRIC SHOCK HAZARD

9.1 Accessible Parts — Accessible parts shall not be live. Live parts shall therefore be protected by covering or insulation.

For protection of terminals, *see* **9.3.7**.

Coatings of lacquer, enamel, oxides, anodic films, non-impregnated paper, fibres and fibrous materials, wood and potting with compounds (except self-setting resins) are, in general, not regarded as insulation for the purpose of protection against shock hazards, because the insulation may be damaged by breaking of brittle coatings or scratching of films or soft coatings.

In order to determine whether a part is accessible, both the rigid test finger of Fig. 1, and the jointed test finger of Fig. 2 are applied in every possible position. In case of doubt, the rigid test finger is applied with a maximum force of 30 N. The test is carried out on all outer surfaces, including the bottom. The force shall be exerted by the tip of the test finger so as to avoid wedge and lever action.

An electrical contact indication with a voltage of approximately 40 V is recommended to show contact with conductive parts.

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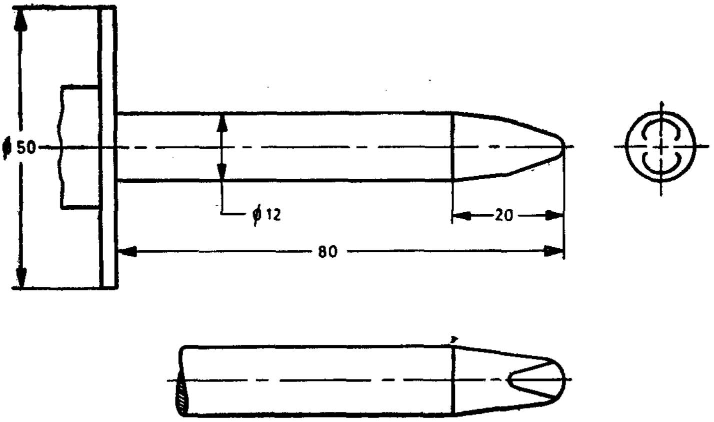
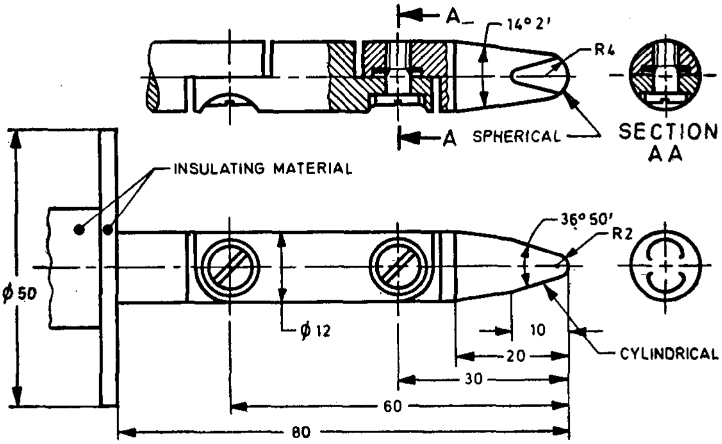
*Safety requirements for mains-operated electronic and related apparatus for household and similar general use (*first revision*).



Dimensions in millimetres.

Dimensions of the fingertip: see Fig. 2

FIG. 1 RIGID TEST FINGER



Dimensions in millimetres.

Tolerances:
on angles: ± 5′
on linear dimensions
less than 25 mm: −0·05
over 25 mm: ±0·2

FIG. 2 JOINTED STANDARD TEST FINGER

9.2 Live Parts

9.2.1 In order to determine whether a part is live or not, the following measurements are carried out, between any part and earth, the apparatus being under reference test conditions and earthed.

For the purpose of this test, apparatus, being earthed denotes that all terminals which may be simultaneously connected to earth under normal operating conditions are connected with one another and earth, and that the apparatus is set up on a conductive earthed surface.

The test applies to both exterior and interior parts of the apparatus.

The part is not live if the voltage measured with a voltmeter, having an internal resistance of near to, but not less than, 50 k Ω does not exceed the limits of extra-low voltage.

For frequencies above 1 kHz, the limit of 0·3 mA (peak) is multiplied by the value of the frequency, in kilohertz, with a maximum of 30 mA (peak).

The values stated for the capacitance are rated values.

In case of doubt, it shall also be verified that no voltages or currents exceeding the specified values are present between two accessible parts.

9.2.2 Conductive parts of Safety Class II apparatus, insulated from live parts by functional insulation only are considered to be live parts.

9.2.3 Parts of Safety Class III apparatus are considered to be live parts if the operating voltage is obtained directly from the supply mains without the use of an isolating device (*see* **2.3.5**).

This implies that the user shall be protected against the touching of parts at safety extra-low mains voltage, as Safety Class III apparatus shall be admitted for use in extra-hazardous locations.

9.3 Exterior of the Apparatus

9.3.1 *Operating Shafts* — Operating shafts shall not be live.

Compliance is checked by performing the measurements specified in **9.2**, after removing knobs, handles and the like, unless they are moulded or captive on the shaft and the means for removing such handles or knobs is not accessible.

9.3.2 *Knobs, Handles and the Like* — External handles, knobs and the like, which operate component parts at mains voltage shall be made of insulating material, unless they are connected to those component parts by an insulating shaft or support, or unless the component parts have been tested in accordance with the specifications concerning protective impedance (*see* **14**).

For toggle switches and sensitive (snap-action) switches which have metal handles and are used as mains switches, *see* **13.4.4**.

Compliance is checked by inspection.

9.3.3 *Ventilation Holes* — Ventilation and other holes over live parts shall be so designed that a suspended foreign body introduced into the apparatus will not come into contact with any live part.

Compliance is checked by inserting through the holes a metal test pin with a diameter of 4 mm and a length of 100 mm. The test pin is suspended freely, the penetration being limited to its length.

The test pin shall not become live.

9.3.4 *Preset Controls* — If a hole gives access to preset controls and the setting of these controls requires a screwdriver or some other tool, the adjustment of the control shall not involve the risk of electric shock.

Compliance is checked by setting the control with any suitable tool. The tool shall not become live.

9.3.5 *Mains Voltage Adjustment* — The operation of changing by hand the setting for the voltage or nature of supply shall not involve a risk of electric shock.

Compliance is checked by application of the test of **9.2**.

The directions given by the manufacturer are to be observed when performing this test.

9.3.6 *Use of Wood* — The insulation of live parts shall not be provided by non-impregnated wood.

The enclosure may be made of non-impregnated wood, subject to the conditions applicable to a metal enclosure used as a mechanical barrier.

Compliance is checked by inspection.

9.3.7 *Terminals* — The requirements of **9.1** apply also to:

a) measuring and protective earth terminals, and terminals for headphones which, therefore, shall not be live;

b) terminals which are energized from the interior with live or floating voltages exceeding 1 kV which, therefore, shall not be accessible; and

c) terminals which receive a charge from an internal capacitor. They shall not be live 10 s after interruption of the supply.

Compliance is checked by the application of the test of **9.2**.

The requirements of **9.1** do not apply to external terminals and sockets, other than those indicated above, of operational and measuring circuits if not feasible for operational reasons. These terminals shall be protected against unintended contact as far as possible by covering, recessing or by their positioning and arrangement or, if these measures are not applicable, by properly marking them.

9.3.8 *Built-in Apparatus* — The requirements of **9.1** do not apply to apparatus intended to be built-in, if and in so far as protection against contact of live parts is to be obtained by mounting.

9.4 After Removal of Detachable Parts

9.4.1 A part which is exposed by removal of a cover or another detachable part (for example, a plug-in unit) by hand shall not be live; terminals and sockets are exempted within the limits of **9.3.7**.

Parts which become accessible during normal operation shall not be live, even if the cover or door is opened by a key or the like.

Compliance is checked by the application of the tests of **9.2** and **9.3**.

9.4.2 Covers intended to be removed during operation, making parts accessible which are energized from the interior with live or floating voltages exceeding 1 kV, and the parts thus made accessible shall be marked with a red-coloured flash [*see* **5.5** (c)].

Compliance is checked by inspection.

9.5 Constructional Requirements

9.5.1 *Subdivision of Circuits into Groups* — For the purpose of the following clauses, circuits of electronic measuring apparatus are divided into two groups. To each of these groups particular safety requirements apply. These groups are as follows:

a) Circuits conductively connected to the supply mains (*see* **2.6.4**) and equivalently:
    i) circuits designed to be conductively connected or to supply live measuring or control voltages; and
    ii) circuits and parts not sufficiently insulated from these circuits.

b) Other circuits.

Gas discharge, vacuum and semiconductor paths are regarded as not providing sufficient insulation for the purpose of this standard.

Internal circuits carrying live voltages are not to be considered under (a).

9.5.2 *Application of Protective Measures*

a) The constructional requirements of **9.5.3** to **9.5.9** and protection requirements in accordance with Safety Classes I, II and III apply to the circuits defined in **9.5.1** (a).

The Protection is required for the defined circuits only. However, it is understood that a substantial and continuous enclosure used as protection will in general cover the whole apparatus.

In particular cases, protective measures are also imposed on other interior circuits which include live parts (*see* **9.5.10**).

b) Neither constructional requirements of **9.5.3** to **9.5.10** nor protection requirements in accordance with Safety Classes I, II or III will consequently be imposed on apparatus which:

neither includes live parts in the interior,

nor is intended to be connected to mains or live circuits.

9.5.3 *General Mechanical Requirements* — The following requirements apply to parts and circuits as defined in **9.5.1** (a).

a) The construction of the apparatus shall be such as to prevent short-circuiting of the insulation between parts of circuits connected to the supply mains and/or their equivalents, and accessible conductive parts due to accidental loosening or freeing of the wiring, screws, etc.

The requirement is deemed to be fulfilled if the apparatus withstands the mechanical tests specified in **11**.

b) The rigidity of wiring connections which are subject to mechanical stresses shall not depend only upon soldering.

This requirement does not apply to the wire leads of components in printed circuits and the like.

Wiring rigidity shall be provided by cable clamps or cable lacing, or by using an insulating tube of proper diameter to protect the wiring from mechanical stresses.

c) Screws which fix back covers, bottom covers, etc, and whose length determines a creepage distance or clearance between accessible parts and live parts shall be captive.

d) Interchangeable parts which determine clearances or creepage distances shall be appropriately marked so as to avoid faulty insertion.

Compliance with (b) to (d) is checked by inspection.

9.5.4 *Creepage Distances and Clearances*

a) The creepage distances and clearances between:

   i) parts of circuits as defined in **9.5.1** (a);

   ii) and accessible conductive parts, parts connected to them including any accessible area of a non-conductive part (*see* Fig. 3, as an example) or a test finger applied as specified in **9.1**;

shall be at least those specified in Table 2, and correspond to the voltage to which the insulation is subjected under normal operating conditions.

Creepage distances and clearances between these circuits are subjected to testing under fault conditions, unless they comply with the values of Table 2 (*see* **10.3.3**).

Mains supply circuits shall comply with the values of Table 2 after a force of 2 N has been applied against any non-insulated part or wire.

Compliance is checked by inspection and measurement.

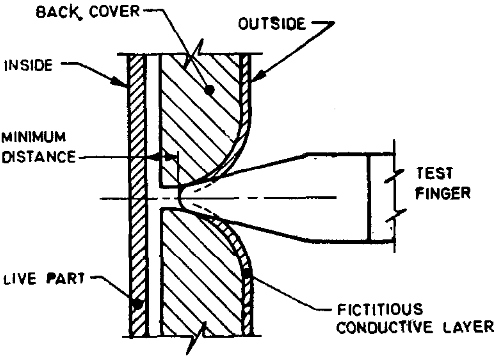


Fig. 3 Accessible Part

b) If an insulating part contains a groove of less than 1 mm width, the creepage distance is not measured over the surface of the groove but only across its width.

If a clearance consists of two or more air gaps in series, any gap of less than 1 mm width is ignored in calculating the total distance.

If an insulating barrier consists of two parts between which there is a capillary slit (an assembly gap), the path along the slit must be taken into account when measuring creepage distances and clearances.

The illustration of the measurement of creepage distances and clearances are given in IS : 616-1981*.

The specified creepage distances and clearances are the minimum actual separations taking into account tolerances in assemblies and components.

The voltages mentioned in Table 2, are determined with the apparatus connected to the rated supply voltage after the steady-state has been reached.

Creepage distances and clearances are measured with connectors and plugs in their normal positions.

For voltages over 2·5 kV, the voltage test (*see* **9.7.4** and Table 3) is used to determine whether the creepage distances or clearances are adequate or not.

c) The interior of a reasonably dust-proof apparatus is exempted from requirements concerning creepage distances and clearances. For this purpose, the following types of apparatus or parts of them are considered to have a reasonably dust-proof enclosure.

1. Apparatus containing an electro-mechanical measuring instrument.

   In general, all those parts which are covered in the same way as the mechanism are considered to have a reasonably dust-proof enclosure.

2. Other apparatus when complying with a dust test.

   The apparatus is subjected to the test described in IS : 616-1981* under the first characteristic numeral 5, but for 2 h only and without application of vacuum.

   Immediately before being placed in the test chamber, the apparatus shall be operated under reference test conditions until thermal equilibrium has been reached.

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*Safety requirements for mains-operated electronic and related apparatus for household and similar general use (*first revision*).

The apparatus is considered to have a reasonably dust-proof enclosure if none of the clearances and creepage distances specified in **9.5.4** (a) or in other parts of this standard is bridged by a continuous layer of talc.

3. Parts which are covered by a solid insulation moulding are also considered to be reasonably dust-proof.

9.5.5 *Safety Class I Apparatus* — All accessible conductive parts of the apparatus, susceptible of becoming live in the event of a fault, shall be bonded electrically to the protective earth terminal.

For this purpose, protective earth connections between self-contained units of an apparatus shall not rely solely on an exterior metal braid of a connecting cable.

The connection between the protective earth terminal and the accessible conductive parts shall be provided by one of the following means:

a) Directly, by a well-conducting connection.

Compliance is checked, as a routine test, by inspection and in case of doubt by measuring the resistance between the protective earth terminal and the accessible conductive parts. A current of 25 A shall be used for this measurement. The resulting voltage drop across the resistance shall not exceed 12·5 V corresponding to 0·5 Ω.

For his continuity test, it may be necessary to provide means by which connection to the accessible conductive parts can be made. This means of connection shall be capable of carrying the current specified above.

b) Indirectly, by an intermediate device which establishes a connection between the protective earth terminal and the accessible conductive parts when these become live.

Such intermediate devices are:

1. Voltage limiting devices which become conductive when the voltage across them exceeds the limits of extra-low voltage.

The use of these devices presupposes that the apparatus is adequately fused to prevent breakdown of the device. For this purpose, internal fuses shall protect all poles of the mains supply. For external fuses, reference is made to **17.3.2** (c).

Compliance tests are performed after having connected the accessible conductive parts to one of the mains supply terminals, and by applying rated mains supply voltage to the input of the apparatus. The voltage to earth of the accessible conductive parts shall not exceed the limits of extra-low voltage for more than 0·2 s.

2. Voltage sensitive tripping devices which interrupt all poles of the mains supply, and connect the accessible conductive parts to the protective earth terminal when the voltage across them exceeds the limits of extra-low voltage.

   Compliance is checked, as a routine test, by applying a voltage equal to the limits of extra-low voltage between the accessible conductive parts and the protective earth terminal. The tripping action shall take place within 0·2 s.

c) The protective earth terminal may alternatively be connected to a well-conducting protective screen. The screen shall separate the mains circuits and their equivalents from all other circuits and shall be insulated from them to withstand the tests of **9.7**.

   A connecting link may allow connection of this screen to the accessible conductive parts.

   Compliance is checked by performing the tests specified in **9.7**. Regarding the connection to the protective earth terminal, compliance is checked, as a routine test, by inspection and, in case of doubt, by measuring the resistance between the protective earth terminal and the screen. A current of 25 A shall be used for this measurement and the resulting voltage drop across the resistance shall not exceed 12 V.

   For this continuity test, it may be necessary to provide means by which connection to the screen can be made. This means of connection shall be capable of carrying the current specified above.

9.5.6 *Safety Class II Apparatus* — Safety Class II apparatus shall not be provided with a protective earth terminal.

Measuring earth terminals, however, are permitted.

For Class II apparatus with a live chassis and enclosure partly or wholly of metal, or with a chassis which is insulated from this conductive enclosure, protection shall be assured by:

a) Covering the inside of the enclosure with an insulating coating equivalent to an insulating enclosure surrounding the whole chassis and all places where a loosened live part might touch the enclosure; or

b) designing the apparatus in such a way that the creepage distances and clearance between the chassis or other live parts and the enclosure cannot be reduced to less than 50 percent of the values specified in Table 2, by parts or wires becoming loose.

For the purpose of this requirement:

i) it is not expected that two independent faults will occur simultaneously;
ii) screws or nuts with lock washers are not regarded as liable to become loose; and
iii) wires which are mechanically secured, apart from by soldering, are not regarded as liable to become loose.

9.5.7 *Safety Class III Apparatus*

Class III apparatus shall not be provided with a protective earth terminal.

Compliance is checked by inspection.

Class III apparatus is exempted from the requirements of **9.5.4**.

Apparatus which is fed by safety extra-low voltage but generates a live voltage, however, shall comply with Class I or II requirements for the circuits concerned.

9.5.8 *Combination of Protective Measures* — For Safety Class I apparatus containing more than one separate part or circuit to be protected by earthing, or containing circuits protected according to Safety Class II, the requirements and tests described herein apply separately to each circuit according to its protection.

Protective measures shall, however, be combined only in such a way that they do not cancel one another.

Compliance is checked by examination of the apparatus and its circuit diagram.

9.5.9 *Measuring and Control Circuits* — Measuring and control circuits intended to be connected to live floating voltages shall not be connected to accessible conductive parts of the apparatus. Circuits designed to be always operated with one terminal at earth potential may have this terminal connected to accessible conductive parts.

In the latter case, the connection of the terminal to accessible conductive parts shall either be self-evident (*see* **15.1.3**) or the terminal shall be marked with the symbol ⊥.

Compliance is checked by inspection.

No internal connection of accessible conductive parts to mains circuits including the neutral is allowed (*see also* **4.2.2**, last paragraph).

9.5.10 *Internal Circuits* — Circuits, other than those defined in **9.5.1** (a) but which include live parts, shall be so arranged that accidental loosening or freeing of the wiring, screws, etc, will not cause accessible parts to become live.

This requirement is deemed to be fulfilled.

i) If a protective measure of Safety Class I or II is applied so as to include these circuits, or
ii) If the apparatus has no earth connection at all, or
iii) If these circuits are surrounded by a conductive screen which in the absence of any other earthing point is connected to the measuring earth terminal.

Compliance is checked by inspection.

9.6 Parts Directly Connected to the Supply Mains — Creepage distances and clearances between parts directly connected to the supply mains shall have at least the values given in Table 2.

Compliance is checked by inspection and measurement.

9.7 Humidity Preconditioning and Requirements for Insulation — The insulation of the apparatus shall be adequate so as to have a sufficient insulation strength to prevent breakdown or flashover and a sufficient insulation resistance to prevent excessive leakage currents or thermal breakdown.

Compliance is checked by performing the tests specified in **9.7.1** to **9.7.4**.

9.7.1 *Humidity Preconditioning*

The safety of the apparatus shall not be impaired by humid conditions which may occur in normal use.

Compliance is checked by humidity preconditioning described in this sub-clause followed immediately by the tests of **9.7.3** and **9.7.4**.

TABLE 2 CREEPAGE DISTANCES AND CLEARANCES IN MILLIMETRES FOR PARTS AND CIRCUITS DEFINED IN 9.5.1 (a)

[*Clauses* 9.5.6 (b) *and* 9.6]

RATED VOLTAGE OR ISOLATION VOLTAGE (*See* NOTE 1)		AGAINST ACCESSIBLE CONDUCTIVE PARTS OF SAFETY CLASS II APPARATUS		AGAINST ACCESSIBLE CONDUCTIVE PARTS OF SAFETY CLASS I APPARATUS AND AGAINST OTHER CIRCUITS OF ALL APPARATUS	
(1)		(2)		(3)	
dc or ac, rms if Sinusoidal	ac Peak or Combined Voltage	Clearance	Creepage distance	Clearance	Creepage distance
Up to 24 V	Up to 34 V	2 (1)	2 (1)	1 (0·5)	1 (0·5)
Over 24 up to 60	Over 34 up to 85	3 (2)	3 (2)	2 (1)	2 (1)
Over 60 up to 130	Over 85 up to 184	3·5 (2·5)	3·5 (2·5)	2·5 (1·5)	2·5 (1·5)
Over 130 up to 250	Over 184 up to 354	4 (3)	4 (3)	3 (2)	3 (2)
Over 250 up to 450	Over 354 up to 630	5	7	3·5	4·5
Over 450 up to 660	Over 630 up to 920	6	9	4	6
Over 660 up to 1 000	Over 920 up to 1 400	8	13	5·5	9
Over 1 000 up to 1 500	Over 2 100 up to 2 100	15	18	10	12
Over 1 500 up to 2 000	Over 2 100 upto 2 800	18	21	12	14
Over 2 000 up to 2 500	Over 2 800 up to 3 600	20	23	14	15·5

NOTE 1 — The isolation voltage is the voltage which stresses the insulation at reference test condition (dc or ac voltage, or, for a combined voltage, the sum of both).

NOTE 2 — The smaller values indicated in parantheses apply to miniature type components (printed circuits, micro-modules, etc) and parts in which the design and construction do not provide larger spacings, and may be accepted only where the spacings are rigidly maintained by constructional means and cannot be reduced during assembly of the component or part into the apparatus.

NOTE 3 — For Safety Class II apparatus with double insulation, the values of 3 apply both to functional insulation and to protective insulation separately.

Electrical components, covers and other parts which can be removed by hand, are removed and subjected, if necessary, to humidity preconditioning together with the main part.

Humidity preconditioning is carried out in a humidity chamber containing air with a relative humidity between 91 and 95 percent. The temperature t of the air at all places where the apparatus can be located, is maintained at $40 \pm^{0}_{2}$ °C.

Before being placed in the chamber, the apparatus is brought to a temperature between t and $t+4$°C. The apparatus is kept in the chamber for 48 h.

In most cases, the apparatus may be brought to the specified temperature by keeping it at this temperature for at least 4 h before humidity preconditioning.

Some methods of achieving the specified relative humidity are described in IS : 8145-1976*.

The air in the chamber shall be stirred, and the chamber shall be so designed that mist or condensed water do not precipitate on the apparatus.

After this preconditioning, the apparatus shall show no damage in the sense of this standard.

9.7.2 *Performance of Tests* — Immediately after humidity preconditioning, the insulation and voltage tests specified in the following sub-clauses shall be performed.

The apparatus is inoperative during humidity preconditioning and the actual tests, and shall have been removed from the humidity chamber before these tests.

No humidity preconditioning shall be made before performing routine tests.

Apparatus having an enclosure wholly or partly made of insulating material shall after humidity preconditioning be wrapped in a metal foil to within a distance of not more than 20 mm from the terminals of the apparatus.

9.7.3 *Insulation Resistance Tests*

a) Circuits according to **9.5.1** (a) of Safety Class I or III apparatus.

The insulation resistance between the short-circuited mains circuits including the circuits regarded as equivalent on the one hand, and all other circuits accessible from the exterior and the enclosure on the other hand, shall be measured when steady state has been reached and at least 5 s after applying a dc voltage of about 500 V.

For circuit operating voltages up to 500 V, the insulation resistance shall not be less than:

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*Test chambers of non-injection type for constant relative humidity.

i) 2 M Ω for functional insulation of Safety Class I or II apparatus;

ii) 5 M Ω for supplementary (protective) insulation; and

iii) 7 M Ω for reinforced insulation and for protective impedances, also for double insulation when no separate test of its parts is made.

For circuit operating voltages exceeding 500 V, these values shall be multiplied by the ratio: operating voltage divided by 500 V.

b) Other circuits of Safety Class I or II apparatus and circuits of Safety Class III apparatus.

The insulation resistance of all circuits which are not connected to accessible conductive parts shall be measured between these circuits and the enclosure when steady state has been reached, and at least 5 s after applying dc voltage of about 100 V.

For circuit operating voltages up to 500 V, the insulation resistance shall not be less than 1 M Ω. For circuit operating voltages exceeding 500 V, this value shall be multiplied by the ratio: operating voltage divided by 500 V.

c) Resistors and other components in parallel with the insulation to be tested may be disconnected during these tests.

9.7.4 *Voltage Tests*

a) Voltage tests shall be applied to the insulations, using the test voltages shown in Table 3.

For repetition tests, the following applies unless otherwise agreed to between the manufacturer and the user:

If the test voltage does not exceed 2 kV, the apparatus may be subjected to the necessary number of tests, each of them being performed at 100 percent test voltage.

For apparatus, the test voltage of which exceeds 2 kV, two tests are permitted (that is, one repetition) each of them at 100 percent test voltage. Further repetition tests should be performed at 80 percent of the specified test voltage.

b) Voltage tests shall be performed with a sinusoidal voltage, having a distortion factor not exceeding 5 percent, and with a frequency between 45 and 65 Hz. The test voltage shall be raised gradually to its specified value and by such steps that no appreciable transients occur, maintained for 1 min, and then reduced smoothly to zero.

A source of about 5 mA is, in general, sufficient and show breakdown even if a resistor is incorporated in the flashover circuit.

c) Voltage tests shall also be performed as routine tests. However, routine tests shall be performed only for circuits which are provided with terminals, and for the accessible conductive parts, and wrapping in a foil, if this is required for the type test, they shall be omitted.

Routine tests may also be performed by raising the test voltage within 2 s to its specified value and maintaining it for a further period of 2 s.

d) During the voltage test, no breakdown or flashover shall occur.

Corona effects and similar phenomena are disregarded.

e) Voltage tests shall not be applied to circuits as far as they are regarded as connected to, or as not isolated from, one another or accessible conductive parts. These circuits shall be connected to one another or to the accessible conductive parts, respectively, during voltage tests.

According to **9.5.1**, the term 'not insulated' applies especially to separations by gas discharge, vacuum and semiconductor paths.

f) Suppression capacitors between the mains conductors and accessible conductive parts shall not be disconnected during routine tests.

If, in respect of these capacitors, it is impracticable to perform the test with an ac voltage, a dc voltage equal to 1·4 times the prescribed ac test voltage may be used.

Resistors in parallel with the insulation to be tested shall be disconnected. Tests needing such disconnection shall be performed as type tests only.

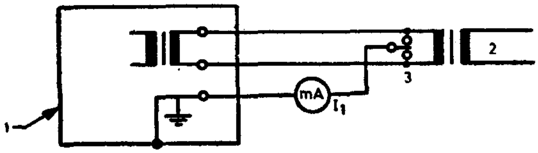
g) Semi conductor components, which due to electric field effects might be damaged during voltage tests, may be disconnected, short-circuited or replaced by dummies during type tests. For routine tests, circuits which contain such components are tested at half the voltage prescribed in Table 3, with a lower limit of 1 kV.

9.8 Leakage Current — The insulation shall remain adequate when the apparatus is used for its intended purpose.

Compliance is checked by the following test which determines the leakage current.

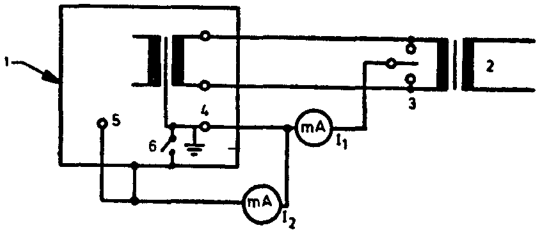
9.8.1 The apparatus shall be set up on an insulated base and shall be operated with 1·1 times the rated supply voltage until it has reached steady state temperature. If different voltages can be set, 1·1 times the highest rated voltage shall be applied.

The leakage current shall be measured for the connections shown in Fig. 4 to 6 between each pole of the mains supply in turn and all accessible conductive parts connected together (including the measuring earth terminal) and/or, for apparatus with an enclosure made of insulating material, a metal foil applied as specified in **9.7.2**.



1 — Accessible conductive parts
2 — Supply mains
3 — Changeover switch

Fig. 4 Set-up for Measuring the Leakage Current of Safety Class I Apparatus, Protective Earth Terminal Directly Connected



1 — Accessible conductive parts or metal foil wrapped around the apparatus
2 — Supply mains
3 — Changeover switch
4 — Protective earth terminal
5 — Measuring earth terminal
6 — Connection link [see 9.5.5(c)]

Fig. 5 Set-up for Measuring the Leakage Current of Safety Class I Apparatus, Protective Earth Connection Indirectly Connected

TABLE 3 TEST VOLTAGE

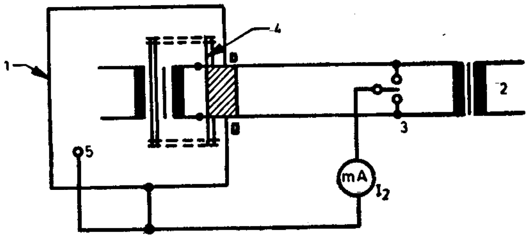
[*Clause* 9.7.4 (a)]

		Rated voltage or isolation voltage *U*is (*see* NOTE 1)		
SL No.	INSULATIONS TO BE TESTED	dc OR ac rms IF SINUSOIDAL	ac PEAK OR COMBINED VOLTAGE	TEST VOLTAGE kV
(1)	(2)	(3)	(4)	(5)
i)	Insulations between each of the circuits described in **9.5.1** (a)	Up to 60 V	Up to 85 V	0·5
ii)	Insulations between these circuits and the enclosure of safety class I apparatus	Over 60 up to 130 Over 130 up to 250 Over 250 up to 650	Over 85 up to 184 Over 184 up to 354 Over 354 up to 920	1 1·5 2
iii)	Insulations between these circuits and protective screens in accordance with **9.5.5** (c)	Over 650 up to 1 000	Over 920 up to 1 400	3
iv)	When parts of double insulation are to be tested separately, both the functional insulation and the protective insulation	Over 1 000 up to 1 500 Over 1 500 up to 2 000 More than 2 000	Over 1 400 up to 2 100 Over 2 100 up to 2 800 More than 2 800	4 5 Nearest whole number of kilovolts higher than the value: $2U_{is}+1\ 000$ V
v)	Insulations between circuits described in **9.5.1** (a) and the enclosure of safety Class II apparatus	Up to 60 V Over 60 up to 130 Over 130 up to 250	Up to 8 V Over 85 up to 184 Over 184 up to 354	0·75 1·5 3

vi) Insulations between main circuits and circuits supplying power at extra low voltage to the exterior, such as power outlets to other apparatus, unless they are separated by a protective screen in accordance with **9.5.5** (c) and insulations between the input and the output of substitute power supplies	Over 250 up to 650 Over 650 up to 1 000 Over 1 000 up to 1 500 Over 1 500 up to 2 000 More than 2 000	Over 354 up to 920 Over 920 up to 1 400 Over 1 400 up to 2 100 Over 2 100 up to 2 800 More than 2 800	4 6 8 10 Twice the nearest whole number of kilovolts higher than the value: $2U_{is}+1\ 000$ V
vii) Insulations between all other circuits described in **9.5.1** (b) of Safety Class I or II apparatus and the enclosure During all voltage tests, these circuits shall be connected together; during the tests of lines 1 to 6, they shall also be connected to the enclosure			$2U_{is}+200$ V or 500 V, whichever is the higher value
viii) Insulations between the circuits of Safety Class III apparatus and the enclosure During this test, the circuits shall be connected together			500 V

NOTE 1 — The isolation voltage U_{is} the voltage which stresses the insulation at reference test conditions (dc or ac voltage, or, for a combined voltage, the sum of both).

NOTE 2 — If there are several rated supply voltages, the test voltage shall be selected on the basis of the highest rated supply voltage.



1 — Accessible conductive parts or metal foil wrapped around the apparatus
2 — Supply mains
3 — Changeover switch
4 — Protective insulation
5 — Measuring earth terminal

FIG. 6 SET-UP FOR MEASURING THE LEAKAGE CURRENT OF SAFETY CLASS II APPARATUS

9.8.2 The leakage current is not excessive:

a) If for the accessible conductive parts, the measuring earth terminal and the foil, as applicable, the voltage measured with a voltmeter having an internal resistance of near to, but not less than, 50 k Ω does not exceed the limits of extra-low voltage; or

b) If, at higher voltages, the measured currents from the mentioned parts do not exceed the limits specified in Table 4. These shall be measured using ammeters having a nominal internal resistance of 2 k Ω (including, if required, a series resistor) which are connected as shown by Fig. 4 to 6.

TABLE 4 LIMITING VALUES OF LEAKAGE CURRENT

SL No.	APPARATUS BELONGING TO	SET-UP AS SHOWN BY	LEAKAGE CURRENT I_1	LEAKAGE CURRENT I_2
(1)	(2)	(3)	(4)	(5)
i)	Safety Class I, protective earth terminal directly connected according to **9.5.5** (a)	Fig. 4	5 mA (peak) ac 5 mA dc	—
ii)	Safety Class I, protective earth terminal indirectly connected according to **9.5.5** (b) or **9.5.5** (c)	Fig. 5	5 mA (peak) ac 5 mA dc	0·7 mA (peak) ac 2 mA dc
iii)	Safety Class II	Fig. 6	—	0·7 mA (peak) ac 2 mA dc
iv)	Safety Class III		No leakage current test	

9.8.3 The leakage current measurement shall also be performed on measuring and control circuits which are intended to be operated at live voltages. The highest permissible measuring or control voltages shall be applied or be set, and the sum of all measured voltages or leakage currents shall not exceed the values indicated in **9.8.2**.

Measurements shall be performed with substantially sinusoidal voltages. For frequencies above 1 kHz, the permitted limits are multiplied by the value of the frequency in kilohertz with a maximum of 30 mA (peak).

The value of 0.3 mA applied to all apparatus is quite sufficient to prevent any uncomfortable perception.

It may be advisable to separate the apparatus by a double-wound transformer from the mains supply when performing this test.

10. TESTING UNDER FAULT CONDITIONS

10.0 When fault conditions are applied to particular parts of the apparatus, no part shall reach a temperature exceeding specified limits, nor shall flammable gases be liberated to such an extent that there is a danger of spread of fire, nor shall the protection against electric shock hazard be impaired.

Fault conditions are described in **10.3**.

10.1 Test Procedure — Compliance with shock protection requirements is checked by performing the tests specified in **9.2** after application of the conditions of **10.3**, and after removal of covers or parts which can be removed by hand.

Compliance with heat and fire protection requirements is checked by performing the test specified in **7.2**, and after application of the conditions of **10.3**.

10.2 Verification — Temperature rises shall not exceed the values indicated in Table 1.

10.2.1 If the temperature is limited by the operation of thermal cut-outs or fusing resistors, the temperatures are measured 2 min after the operation of the device. If there is no temperature-limiting device or if the device does not operate, the temperatures are measured after a steady state has been reached, but not later than 4 h after the start of the test.

If the temperature is limited by a fuse, the following additional test is carried out in case of doubt.

The fuse is short-circuited during the test and the current through it, under the relevant fault conditions, is measured. The apparatus is then operated for a duration corresponding to the maximum fusing time of the type of fuse, as specified for the current measured above. Temperatures are measured 2 min after the end of the period of operation.

In determining the current through the fuse, it should be remembered that this current may vary as a function of time. It should, therefore, be measured as soon as possible after switching on, taking into consideration the heating time of the apparatus, especially where electronic valves are used.

10.2.2 To check whether gases liberated from component parts are flammable or not, a test with a high-frequency spark generator is done. During this test, no explosion shall occur and any flames produced shall not continue to burn for more than 10 s after removal of the spark generator. The sparks shall be applied to those components which are likely to liberate flammable gases.

10.2.3 To verify that neither the insulation strength nor the creepage distances and clearances have been inadmissibly reduced, it may be necessary to repeat insulation tests after having eliminated fault conditions.

The melting of insulating materials, which is not of importance within the sense of this standard, is neglected.

10.3 Application of Fault Conditions — Fault conditions shall be applied to Safety Class I and II apparatus in the manner given below and to the parts and components as follows:

Examination of the apparatus and its circuit diagram will generally show the fault conditions which are liable to result in infringements and which, therefore, shall be applied. These are applied successively in the order which is most convenient.

10.3.1 Coatings of lacquer, enamel, oxides, anodic films, and insulations of non-impregnated paper, fibres and fibrous materials, wood, and compounds (except self-setting resins) which might determine the protection against electric shock from accessible conductive parts, are short-circuited.

Fault conditions are not applied to materials of which the mechanical strength and reliability have been verified by other suitable tests.

10.3.2 Gas-discharge, vacuum and semiconductor paths are short-circuited when they determine a separation between any pair of the following circuits: the mains circuit, one of the measuring and control circuits, or one of the circuits which are operated at live voltage under reference test conditions.

These paths shall also have been short-circuited during the voltage test (*see also* **9.5.1**).

However, during testing under fault conditions, short circuiting of these paths might not be necessary if, by the examination mentioned in **10.3** and subsequent calculation, it becomes evident that if short-circuiting were applied, none of the above-mentioned circuits would become live due to voltages introduced from other circuits, and no component would become live due to voltages introduced from other circuits, and no component would be so overloaded as to cause a dangerous condition.

10.3.3 Clearances and creepage distances not complying with the values of Table 2 are short-circuited when they determine a separation between any pair of the following circuits: the mains circuit, one of the measuring or control circuits, or one of the circuits which are operated at live voltage under reference test conditions.

10.3.4 Component parts such as resistors, capacitors and inductors, are short-circuited or, if more unfavourable, disconnected when they determine a separation between any pair of the following circuits: the mains circuit, one of the measuring or control circuits, or one of the circuits which are operated at live voltage under reference test conditions.

If short-circuiting or disconnecting a resistor, a capacitor, or an inductor would cause an infringement of the shock protection, the apparatus is not deemed to be unsatisfactory, but the part concerned shall comply with the requirements of **13**.

10.3.5 *Additional Test, For Safety Class II Apparatus Only* — Resistors, capacitors, transformers and other components which provide a protective impedance between live parts and accessible conductive parts, are short-circuited or disconnected, whichever is more unfavourable. The following poles or parts shall be short-circuited.

a) *Resistors* — One pole with the other(s) and each pole with the resistor body support, if any;

b) *Capacitors* — One pole with the other(s) and each pole with the metal container, if any;

c) *Transformers* — One primary with the secondary winding and each winding with the core and the screen, if any; and

d) *Other Components* — The current-carrying parts with the support, fixed element(s) or the like.

If short-circuiting or disconnecting a resistor, a capacitor, a transformer, or another component would cause an infringement of the requirements, the apparatus is not deemed to be unsatisfactory, but the component concerned shall comply with the requirements of **14**.

10.3.6 Forced cooling by motor-driven fans, if any, is stopped.

10.3.7 Motors which are protected by means of a separate overcurrent or thermal cutout are stopped or prevented from starting, whichever is more unfavourable.

10.3.8 Motors, relays and other electro-magnetic devices intended for short-term or intermittent operation are operated continuously if continuous operation may occur inadvertently, and unless they are incorporated in apparatus for short-term or intermittent operation.

10.3.9 Capacitors of the auxiliary winding circuits of motors, except self-healing capacitors, are short-circuited.

10.3.10 The secondary winding(s) of mains transformers is (are) short-circuited.

Current-limiting impedances directly connected to any secondary winding remain operative during this test.

10.3.11 The output(s) of supply apparatus is (are) short-circuited.

For apparatus having limited short-circuit protection, the application of this test is limited by the specified time.

10.3.12 Apparatus designed to be operated from alternative types of supply, are simultaneously connected to these supplies, unless this is prevented by the construction.

Alternative types of supply are, for example, mains supply, battery or substitute power supply.

11. MECHANICAL STRENGTH

11.1 General — The apparatus shall have adequate mechanical strength. The components shall be reliably fastened and secured. The electrical connections shall be reliable. Internal wiring shall be disposed in such a manner that its insulation is undamaged and will so remain in normal use.

Compliance is checked by inspection and by performing the following tests.

The tests described in **11.2** and **11.3** shall be performed on portable apparatus. For other apparatus, these tests are recommended, but are optional.

The tests are based on the assumption that laboratory or industrial use of the apparatus causes no abnormal stress. These tests may not be sufficient for apparatus such as that used in vehicles.

11.2 Drop Test — The apparatus, standing in its normal position of use on a smooth, hard, rigid surface of concrete or steel, is tilted about one bottom edge so that the distance between the opposite edge and the test surface is 25 mm or so that the angle made by the bottom and the test surface is 30°, whichever condition is less severe.

It is then allowed to fall freely on to the test surface.

The apparatus shall be subjected to one drop about each of its bottom edges.

The apparatus shall not be allowed to topple on to its next face instead of falling back as intended.

11.3 Vibration Test — The apparatus shall be subjected to vibration endurance conditioning by frequency sweeping as specified in IS : 2106 (Part XVI) - 1971*.

The apparatus is fastened in its normal position of use to the vibration generator by means of straps around the enclosure or, if the apparatus is so fitted, on its shock absorbers.

The direction of vibration is vertical, and the conditions are as follows:

Duration	30 min
Amplitude peak	0·15 mm
Sweep frequency range	10 Hz – 55 Hz – 10 Hz
Sweep rate	approximately one octave per minute

11.4 Impact Hammer Test — The apparatus shall be held firmly against a rigid support and subjected to sets of three blows from a spring-operated impact hammer as shown in Fig. 7. The hammer shall be applied to any external part that if broken is likely to expose live parts, including windows, handles, levers, knobs and the like, by pressing the hammer nose perpendicularly to the surface of that part.

It results from this requirement that glass windows should not be used to protect live parts.

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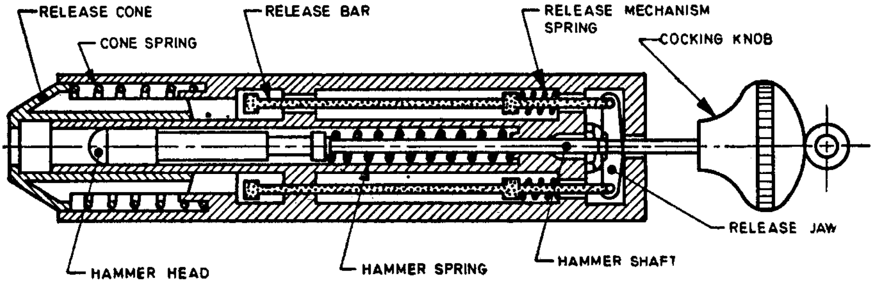
*Environmental tests for electronic and electrical equipment: Part XVI Vibration test.



EXPLANATION

The apparatus consists of three mains parts: the body, the striking element and the spring-loaded release nose.

The body comprises the housing, the striking element guide, the release mechanism and all parts rigidly fixed thereto. The mass of this assembly is 1 250 g.

The striking element comprises the hammer, head, the hammer shaft and the cocking knob. The mass of this assembly is 250 g.

The hammer head has a hemispherical face of radius 10 mm and is of polyamide having a Rockwell hardness of R 100; it is fixed to the hammer shaft in such a way that the distance from its tip to the plane of the front of the nose, when the striking element is on the point of release, is 20 mm.

The nose has a mass of 60 g and the nose spring is such that it exerts a force of 20 N when the release jaws are on the point of releasing the striking element.

The hammer spring is adjusted so that the product of the compression, in millimetres, and the force exerted, in newtons, equals 1 000, the compression being approximately 20 mm. With this adjustment, the impact energy is 0·5 ± 0·05 Nm.

The release mechanism springs are adjusted so that they exert just sufficient pressure to keep the release jaws in the closed position.

The apparatus is cocked by pulling the cocking knob back until the release jaws engage with the groove in the hammer shaft.

The blows are applied by pushing the release nose against the sample in a direction perpendicular to the surface at the point to be tested. The pressure is slowly increased so that the nose moves back until it is in contact with the release bars, which then move to operate the release mechanism and allow the hammer to strike.

FIG. 7 TEST HAMMER

11.5 Conclusions — After these tests the apparatus shall withstand the voltage tests of **9.7.4** and shall show no damage within the sense of this standard. In particular, live parts shall not have become accessible, enclosures shall show no visible cracks, and insulating barriers shall not have been damaged, loosened, or disengaged.

Components which are not designed to withstand transport stresses shall be listed in the instruction manual.

Such components should be removable, or provision made to clamp them down with shipping blocks.

Compliance is checked by inspection.

12. MECHANICAL RESISTANCE TO HEAT

12.1 Resistance to Heat of Insulating Material — Insulating material supporting parts conductively connected to the supply mains, and also covers immediately around such parts, shall be resistant to heat if, under reference test conditions, these parts carry a current exceeding 0·5 A and might produce substantial heat due to imperfect contact.

Compliance is checked by subjecting the insulating material to the test specified in Note 4 to Table 1.

The softening temperature of the insulating material shall be at least 150°C.

Examples of parts which might produce substantial heat are contacts of switches and of voltage adaptors, screw terminals and fuse holders.

A test for the fire resistance of these parts is under consideration.

13. COMPONENTS, GENERAL REQUIREMENTS

13.0 The requirements of this clause apply to all apparatus within the scope of **1.1** unless, for Safety Class II apparatus, **14** imposes more severe requirements.

13.1 Resistors and Inductors — Resistors and inductors, the short-circuiting or disconnecting of which would infringe the requirements of **10.3**, shall be rated for at least twice the dissipation or stress existing under reference test conditions.

Resistors which have been type-tested in accordance with relevant standard for endurance under elevated dissipation, and also resistors and inductors which have been derated in order to obtain a specified accuracy, are deemed to fulfil this requirement.

Bare windings of inductors and windings of wirewound resistors shall be secured adequately.

Compliance is checked by inspection.

13.2 Capacitors — Capacitors, the short-circuiting of which would infringe the requirements of **10.3**, shall be rated for the expected maximum operating temperature and for 1·1 times the operating voltage existing under reference test conditions.

The use of capacitors which have been type-tested in accordance with relevant Indian Standards for endurance under elevated voltage is recommended.

For interference suppression capacitors, reference is made to IS : 3723 (Part I) - 1973*.

Compliance is checked by inspection.

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*Capacitors for radio interference suppression: Part I General requirements and methods of test (*first revision*).

13.3 Motors

13.3.1 Motors shall be constructed to prevent, in extended normal use, any electrical or mechanical failure impairing compliance with this standard. The insulation shall not be affected and contacts and connections shall be such that they do not become loose due to heating, vibration, etc.

Compliance tests may include:

a) Heating tests with 1·1 and 0·9 times the rated voltage in connection with the test of **7.2**;

b) Starting tests with 1·1 and 0·9 times the rated voltage;

c) Endurance tests for motors provided with centrifugal or other automatically operating starting switches.

13.3.2 Motors shall be so constructed or mounted that wiring, windings, commutators, slip-rings, insulation, etc, are not exposed to oil, grease or other substances having a deleterious effect.

Compliance is checked by inspection.

13.3.3 Screw-type brush caps shall be capable of being screwed home to a shoulder or similar abutment and shall engage by at least three full threads.

Compliance is checked by inspection and by manual test.

13.3.4 Moving parts liable to cause personal injury shall be so arranged or enclosed as to provide in normal use adequate protection against this danger. Protective enclosures, guards, etc, shall have adequate mechanical strength. They shall not be removable by hand.

Compliance is checked by inspection and by manual test.

13.3.5 Motors should be so designed that, should the motor be locked or jammed during extended use or should it fail to start, no unsafe temperatures are attained. Alternatively they shall be protected by over current or thermal cutouts.

Compliance tests may be combined with the tests mentioned in **13.3.1**.

13.4 Mains Switches

13.4.1 Apparatus having a power consumption of 25 VA or more shall be provided with a switch in the mains circuit and, if several switches are provided, one of them shall be the principal switch.

For all other apparatus, a mains switch is optional, but is recommended.

Compliance is checked by inspection.

A mains switch is dispensable:

i) for fixed apparatus, if the supply system provides an adequate means of disconnection [*see* **17.3.2** (d)];

ii) for auxiliary devices of the apparatus, such as temperature ovens, battery recharging circuits or timing clocks, if their continuous operation is required; and

iii) if exterior processes are dependent on the continuous operation of the apparatus.

13.4.2 The mains switch or, if several switches are provided, the principal switch, shall disconnect all parts of the apparatus from all poles of the mains. Any switching action shall not cancel the protective action of protective earth connections.

Interference suppression coils and capacitors shall be disconnected from the mains unless otherwise necessary for operational reasons.

For single-phase portable apparatus, mains switches which disconnect only one pole are also acceptable.

Compliance is checked by inspection.

13.4.3 The mains switch or the principal switch shall have adequate breaking capacity.

In case of doubt, compliance is checked by inspection and input current measurement.

For apparatus having an appreciable inrush current or reactive current consumption, dimensioning the switch with regard only to the rated input current may not be sufficient. For switches under capacitive load, reference is made to IS : 616-1981*.

13.4.4 If toggle switches or sensitive snap-action switches with metal handles are used as mains switches, the following shall apply:

Toggle switches shall comply with IS : 3452 (Part I)-1966† and IS : 3452 (Part II)-1970‡. Sensitive switches shall comply with IS : 6089 (Part I)-1971§.

The degree of severity for the long-term damp heat test shall be 25/070/21, and the test voltage and insulation resistance shall be at least those required in this standard (*see* **9.7**) for the mains circuit in which the toggle switch or sensitive switch is used.

Compliance is checked in accordance with the mentioned standards.

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*Safety requirements for mains operated electronic and related apparatus for household and similar general use (*first revision*).

†Toggle switches: Part I General requirements and tests.

‡Toggle switches: Part II Toggle switches, Types I and II.

§Sensitive switches: Part I General requirements and tests.

13.5 Safety Switches — Safety switches, if any, shall interrupt all poles of the supply(ies) to any live part before it becomes accessible. They shall operate satisfactorily even if the enclosure of the apparatus is opened slowly.

Compliance is checked by inspection and by manual test, without, however, trying to maintain an arc.

13.6 Fusing and Interrupting Devices

13.6.1 Apparatus with mains supply shall be protected by fuses, circuit-breakers, thermal switches or the like or, if this is impracticable, by a design providing input current limiting.

Any rupture of a fuse or tripping of a circuit breaker shall not cancel the protective action of protective earth connections.

Compliance is checked by inspection.

Fixed apparatus need not necessarily include built-in fuses if the supply system is protected adequately [*see* **17.3.2** (c)].

13.6.2 If replaceable fuses are used, the fuse rating and the nature of the fuse shall be marked beside or on the fuse holder.

If the apparatus is intended for several mains voltages and if, therefore, the current ratings of the fuses cannot be marked beside or on the fuse holder for lack of space, they should be indicated in the instruction manual provided with the apparatus, and the symbol of **5.3** should be shown adjacent to the fuse holder.

Compliance is checked by inspection.

Fuses shall comply with relevant Indian Standards.

13.6.3 Thermal cutouts shall have adequate rupturing capacity, and shall break the circuit safely when the predetermined temperature has been reached.

Compliance is checked during fault conditions tests.

13.6.4 If live parts are rendered accessible during replacement or resetting of fusing or interrupting device, the means by which access is gained shall not be operable by hand (*see also* **9.4**).

Compliance is checked by inspection.

13.7 Batteries — If live parts are rendered accessible during the replacement of a battery, the means by which access is gained shall not be operable by hand (*see also* **9.4**).

The battery shall be so arranged that there is no risk of accumulation of flammable gases.

Apparatus containing batteries holding liquid shall be so designed that safety cannot be impaired by the leakage of the liquid.

Compliance is checked by inspection.

13.8 Voltage Setting Devices — The apparatus shall be so constructed that changing of the setting from one voltage to another or from one nature of supply to another cannot occur accidentally.

Compliance is checked by inspection and by manual test.

The marking of voltage setting devices is specified in **5.4** (c).

13.9 Screw Connections and Fixings

13.9.1 Screw connections providing contact pressure and screw fixings which during the life of the apparatus will be loosened and tightened several times shall have adequate strength and screws shall screw into a metal nut or a metal insert.

Screw fixings which during the life of the apparatus will be loosened and tightened several times include terminal screws, screws for fixing covers (as far as they must be loosened to open the apparatus), screws for fixing handles, knobs and the like.

Compliance is checked by inspection.

13.9.2 Electrical connections in parts directly connected to the supply mains (*see* **2.6.3**) shall be so designed that contact pressure is not transmitted through insulating material other than ceramic, unless there is sufficient resiliency in the metal parts to compensate for any possible shrinkage of the insulating material.

Compliance is checked by inspection.

13.9.3 A screw or rivet which serves both as an electrical connection carrying mains current and as a mechanical connection shall be secured against loosening.

Sealing by compound or the like provides satisfactory locking only for screw connections not subject to torsion. For rivets, a non-circular shank or an appropriate notch may be a sufficient guard against rotation.

Compliance is checked by inspection and by manual test.

14. COMPONENTS, SPECIAL REQUIREMENTS FOR SAFETY CLASS II APPARATUS

14.1 Resistors, capacitors, transformers, and other components providing the protective impedance of Safety Class II apparatus, and the short-circuiting or disconnecting of which would infringe the requirements of **10.3.5** shall be so designed and constructed as to guarantee safe and reliable operation of the apparatus.

These components, or assemblies including such components, shall be tested in accordance with relevant specifications which include at least:

a) initial measurement of impedance;
b) humidity treatment;
c) endurance test;
d) final measurement of impedance; and
e) voltage test and/or leakage current test.

Test specifications shall also prescribe the number of samples required and indicate the conclusions when one or more samples fail during the test.

Detailed test specifications are contained in IS : 616-1981*.

15. TERMINAL DEVICES

15.1 Accessible Terminals

15.1.1 Accessible terminals for flexible cords shall be so located or shielded that there is no risk of accidental contact between live parts of different polarities or between such parts and other conductive parts even if a strand of a conductor escapes from a terminal.

Compliance is checked by inspection after fully inserting a stranded conductor with an 8 mm length of insulation removed, with one of the wires free. This wire shall not touch parts of different polarities or accessible conductive parts when bent in every possible direction, without tearing back the insulation or making sharp bends round barriers.

15.1.2 Accessible terminals shall be so anchored, fitted, or designed that they will not work loose when they are tightened, loosened, or connections are made.

Compliance is checked by manual test and inspection.

15.1.3 Accessible terminal shall preferably be so arranged that it is self-evident whether or not they are connected to accessible conductive parts.

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*Safety requirements for mains operated electronic and related apparatus for household and similar general use (*first revision*).

A metal base of a terminal (for example, of a coaxial connector) shall be connected to the metal enclosure. A terminal having an insulating base shall not be connected to accessible conductive parts, unless otherwise necessary for operational reasons (*see also* **9.5.9**).

Compliance is checked by inspection.

15.2 Earth Terminals

15.2.1 For protective earth terminals, if any, the following shall apply:

a) For apparatus provided with a connector for the mains supply, the earth contact shall be an integral part of this connector;

b) For apparatus to be connected to fixed wiring or provided with a non-detachable flexible cord or cable, the earth terminal shall be adjacent to the mains terminals.

c) If the apparatus is not designed to be connected to the protective conductor of the mains supply, the protective earth terminal shall be located adjacent to the terminals of that circuit to which the protective earthing applies. If this circuit is provided with external terminals, the protective earth terminal shall also be external.

d) Earth terminals for mains circuits shall be at least equivalent to the mains terminals and shall allow the insertion of a conductor of the same cross section. External earth terminals for measuring and control circuits shall at least be able to accommodate a conductor up to 4mm^2.

e) Soldered connections to the accessible conductive parts or protective screens shall be mechanically secured before soldering; screw connections shall be secured against loosening;

f) All parts of the earth terminals shall be such that there is no danger of corrosion resulting from contact with the copper of the earth conductor or any other metal in contact with them;

g) The contact surfaces shall be metal and the screw and the body of the earth terminal shall be non-corrosive;

h) It shall not be possible to loosen the earth terminal screw by hand, except exterior earth terminals for measuring and control circuits; and

j) Plug in type earth terminals, combined with other terminals and intended to be connected and/or disconnected by hand, shall be so designed that the protective earth connection is established prior to any other connection, and is disconnected later than any other connection when retracting.

Compliance is checked by inspection and by manual test.

15.2.2 Measuring earth terminals, if any, shall allow connection independent of the protective earth connection.

Compliance is checked by inspection.

All kinds of apparatus may be equipped with measuring earth terminals, irrespective of their safety class.

15.3 Plugs and Connectors — Plugs and appliance connectors for the connection of the apparatus to the supply mains and socket outlets for providing power to other apparatus shall comply with the relevant specifications for fixed socket outlets and appliance connectors.

Compliance is checked according to the relevant specifications.

16. EXTERNAL CORDS

16.1 Requirements For External Cords — These requirements apply to external cords (including trailing cables) which are supplied together with the apparatus or are fixed to it.

16.1.1 Mains supply flexible cords and other cords with live conductors shall comply with IS : 694-1977* or IS : 434 (Part I)-1964†.

Compliance is checked in accordance with these standards.

In some countries non-sheathed flexible mains supply cords are not allowed.

16.1.2 Conductors of mains supply cords shall have such a cross-section that, if a short-circuit occurs at the apparatus end of the cord, the protective devices in the electrical installation operate before the core overheats.

Compliance is checked by inspection.

A consequence of this requirement is that the minimum required cross-section for such conductors depends on the local wiring rules.

16.1.3 Conductors of external cords between parts of the apparatus, and of cords used as a connection between the apparatus and other apparatus used in connection with it, shall have a cross-section such that the temperature rise of the insulation under reference test conditions and under fault conditions is negligible.

Compliance is checked by inspection. In case of doubt, the temperature rise of the insulation is determined under reference test conditions and under fault conditions. The temperature rise shall not exceed the values given in the appropriate columns of Table 1.

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*PVC insulated cables for working voltages up to and including 1 100 volts (*second revision*).

†Rubber-insulated cables: Part I With copper conductors (*revised*).

16.1.4 If a cord contains a combination of live conductors and other conductors conductively connected to accessible parts (for example, a remote control cord), the insulations of all conductors shall have the same standard, except any insulation the short-circuiting of which does not cause accessible parts to become live.

Compliance is checked by inspection.

16.1.5 Plugs of supply cords of Safety Class III apparatus and of apparatus intended to be fed by supply sources energizing solely the apparatus concerned shall not fit into mains systems with live voltages.

Compliance is checked by inspection.

16.2 Connection of External Cords

16.2.1 The apparatus shall allow the external cords to be so connected that the connecting points of the conductors are relieved from strain, that the outer covering is protected from abrasion, and that the conductors are prevented from twisting. Moreover, it shall not be possible to push the cords into the apparatus if this involves danger.

Compliance is checked by inspection.

16.2.2 If an insulation fault of the cord or the conductor would make accessible parts live, the devices for strain and twist relief shall either be of insulating material or have a fixed covering of insulating material.

Compliance is checked by inspection and by testing the insulating covering, if any, according to **9.7**.

16.2.3 The positioning of the supply cords inside the apparatus shall be so designed that the conductors can be easily introduced and can be connected without forming sharp bends, and so that the cover, if any, can be fitted without damage to the cord.

The inlet opening shall be such that the cord will not be damaged when moved, for example, by rounding off the edges of the inlet opening or by using an appropriate bushing of insulating material.

Compliance is checked by inspection and by fitting flexible cords.

16.2.4 The green/yellow coloured protective core, if any, shall be correctly connected to the protective earth terminal, and shall not be used for other purposes. It shall be connected in such a way that the live cores break prior to the protective core when the cord is torn off accidentally.

Compliance is checked by inspection.

17. INFORMATION FOR THE USER

17.1 Documentation — The instruction manual specified in IS : 6756-1972* shall, for safety purposes, comply with the requirements of **17.2** to **17.4** which detail the specifications given in a more general form in that standard.

Compliance with **17.2** to **17.4** is checked by inspection.

17.2 Safety Measures — The instruction manual shall indicate the Safety Class of the apparatus and, with Safety Class I apparatus which do not provide a direct connection in accordance with **9.5.5** (a) the means for the connection between the protective earth terminal and the accessible conductive parts or the protective screen in accordance with **9.5.5** (b) or (c).

When several different safety measures are used for an apparatus, the circuits concerned and their safety measures shall be indicated (*see* **9.5.8**).

17.3 Information and Warnings — The texts of **17.3.2** to **17.3.6** shall be included in the instruction manual at appropriate places, as applicable.

The text of **17.3.1** may be included.

17.3.1 This apparatus has been designed and tested in accordance with 'IS : 9858-1981 Safety requirements for electronic measuring apparatus', and has been supplied in a safe condition. The present instruction manual contains some information and warnings which have to be followed by the user to ensure safe operation and to retain the apparatus in safe condition.

The apparatus has been designed for indoor use. It may occasionally be subjected to temperatures between +5° and −10°C without degradation of its safety.

17.3.2 *Installation of the Apparatus*

a) For Safety Class I apparatus connected to fixed wiring:
Before any other connection is made the protective earth terminal shall be connected to a protective conductor.

b) For built-in apparatus in accordance with **9.3.8**:
This apparatus shall be used only when built in.

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*Technical documentation to be supplied with electronic measuring equipment.

c) For fixed apparatus without incorporated fuses, circuit-breakers or the like, in accordance with **13.6.1**:

This apparatus shall be connected to a power supply line which is protected by a fuse (or by fuses) from .... A up to and including .... A.

The dotted margins are to be filled by the manufacturer considering, as necessary, that more than one apparatus may be connected to power supply line.

d) For apparatus without incorporated switch or containing continuously operated parts in accordance with **13.4.1**:

For this apparatus, the power supply line shall contain a switch or another adequate means for disconnection from the mains.

This requirement may be complemented by further specifications, for example, of the breaking capacity of the switch (*see* **13.4.3**).

17.3.3 *Before Switch-on of the Apparatus*

a) For all apparatus:

Before switching on the apparatus, make sure that it is set to the voltage of the power supply.

b) For Safety Class I or II apparatus likely to be energised via an external auto transformer:

If this apparatus is to be energised via in external autotransformer for voltage reduction, make sure that its common terminal is connected to the neutral (earthed pole) of the power supply.

The use of external auto transformers is likely to be necessary for exported apparatus without a voltage setting device.

c) For Safety Class I apparatus with mains cord and plug:

The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord without a protective conductor.

d) For Safety Class I apparatus with live measuring or control circuits:

Before switching on the apparatus, the protective earth terminal(s) shall be connected to a protective conductor.

e) For Safety Class I apparatus with mains cord and plug, and with live measuring or control circuits without protective earth terminal:

The mains plug shall be inserted before connections are made to measuring or control circuits.

f) The texts of (b) to (d) may be modified for apparatus to be used in countries where the operation of Safety Class I equipment, without a protective earth connection, is permitted in particular locations. Such locations will in general be determined by the installation of socket outlets without protective contact.

g) For Safety Class III apparatus:

Before switching on the apparatus, make sure that the intended power supply line is fed by safety extra-low voltage in accordance with regulations.

h) For apparatus liberating gases (*see* **6.4**):

Before switching on the apparatus, make sure that the location is sufficiently ventilated.

As an example, this may apply to stroboscopic measuring equipment in respect of ozone and nitric oxides.

17.3.4 *Conduct of Measurements*

a) For Safety Class I apparatus:

Warning:
Any interruption of the protective conductor inside or outside the apparatus or disconnection of the protective earth terminal is likely to make the apparatus dangerous. Intentional interruption is prohibited.

b) For apparatus intended to be combined with other apparatus or installations:

For the combination of this apparatus with other apparatus and/or for its connection to installations the following applies:

The manufacturer shall state as applicable:
- i) the conditions,
- ii) special connection cords to be used,
- iii) interconnection for potential compensation when several apparatus are in use under the provisions of **17.4** (f).

17.3.5 *Adjustment, Replacement of Parts, Maintenance and Repair*

a) For all apparatus of Safety Classes I, II and III:

When the apparatus is connected to its supply, terminals may be live, and the opening of parts or removal of covers (except those to which access can be gained by hand) is likely to expose live parts.

The apparatus shall be disconnected from all voltage sources before it is opened for any adjustment, replacement, maintenance or repair.

b) For all apparatus of Safety Classes, I, II and III:

Capacitors inside the apparatus may still be charged even if the apparatus has been disconnected from all voltage sources.

Details for the prevention from dangers shall be given by the manufacturer, for example, to retain the mains switch IN the ON position while disconnecting the external source, or by specifying the points to be discharged.

The following sentence is to be added if applicable under the provisions of **9.3.7** (c).

The following terminals are connected to internal capacitors and may remain live for 10 s after disconnecting the apparatus from its power supply.

These terminals are to be indicated by the manufacturer.

c) For all apparatus of Safety Classes I, II and III:

Any adjustment, maintenance and repair of the opened apparatus under voltage shall be avoided as far as possible and, if inevitable, shall be carried out only by a skilled person who is aware of the hazard involved.

d) For all apparatus with built-in fuses:

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of mended fuses and the short-circuiting of fuse holders are prohibited.

17.3.6 *Defects and Abnormal Stresses* — For all apparatus:

> Whenever it is likely that the protection has been impaired the apparatus shall be made inoperative and be secured against any unintended operation.
>
> The procedure then to be followed is to be given by the manufacturer, that is, trouble shooting and repair, and an indication of the tests to be performed thereafter.
>
> For this purpose, a high voltage test will be the most important one, and this and other tests should be prescribed in accordance with this standard.
>
> The protection is likely to be impaired if, for example, the apparatus:
>
> a) shows visible damage,
>
> b) fails to perform the intended measurements,
>
> c) has been subjected to prolonged storage under unfavourable conditions, and
>
> d) has been subjected to severe transport stresses.

The manufacturer should state the limit conditions of operation, storage and transport.

17.4 Marking and Instructions

17.4.1 When the test voltage for repetition tests is limited under the provisions of **9.7.4** (a) or (g), this shall be stated in the instruction manual.

17.4.2 The entries in the instruction manual shall include, and be identical with, the special markings specified in the following clauses and sub-clauses of this standard.

Clause Ref	*Content*
3.2	Indication of the applicable standard
5.3 (a)	Warning symbol
7.1	Special operating conditions
9.5.3 (d)	Interchangeable parts
9.5.9	Terminals connected to accessible conductive parts
11.5	Precautions during transport
13.6.2	Fuse ratings

APPENDIX A

(*Clauses* 0.2.1 *and* 3)

EXPLANATIONS OF SAFETY CLASSIFICATION

A-1. In the present standard, safety classes have been introduced in order to have a simple abbreviation for distinct protection principles. The numerals I to III are not intended as quality indices and, in general, adequate safety may be obtained in different ways.

A-1.1 Safety of electrical equipment can be assured only when its design and the installation requirements of the location where it will be used, match each other. In this respect, for the time being, installation rules are insufficient in many countries, but the following is assumed to be contained in the future installation rules of all countries.

A-1.2 Future Regulations — Probably as far as voltages up to 250 V against earth are concerned, future regulations will have to define as:

a) electrically non-hazardous location which would denote a non-wet location in which it is impossible for the operator to come into contact with conductive parts connected to earth potential;

b) electrically hazardous location which would denote a non-wet location, or with moderate humidity, in which it is possible for the operator to come into contact with conductive parts connected to earth potential; and

c) electrically extra-hazardous location which would denote a non-wet location, or with moderate humidity, in which the operator is normally in contact with conductive parts connected to earth potential. (The requirements for extra-hazardous locations may also be imposed on particular electrical equipment which causes the location where it is operated to become extra-hazardous).

These definitions will not cover any hazards arising from conductive dust, explosive gases, etc, but will in general cover most of the domestic, industrial and laboratory locations where equipment according to Classes 0 to III can be used.

A-1.3 Installation rules will have to specify among other things:

a) the means by which connection is made between the fixed installation and movable or portable equipment, that is, plug and socket connections meeting the intended safety measures;

b) the method by which connection is made between fixed installations and stationary equipment;

c) the requirements for protective earth installations; and

d) the requirements for safety extra-low voltage installations and how to provide them.

Some proposals in this respect are mentioned below.

A-1.4 Further rules will specify the requirements for both equipment and installations such as are encountered, for instance, in:

a) coal mining;

b) exposed chemical industries;

c) ships; and

d) medical practice, etc.

As the special conditions encountered in these surroundings and applications will apply to many kinds of electrical equipment, expert bodies should deal with the necessary requirements. Such requirements, once established, may be adapted to the equipment (apparatus) dealt with in this standard.

A-2. CORRESPONDING TO THE INSTALLATION RULES AS OUTLINED ABOVE, THE FOLLOWING WILL APPLY TO EQUIPMENT (APPARATUS) OF CLASSES 0 TO III

A-2.1 Class 0 Equipment

A-2.1.1 Class 0 equipment denotes that no protection is assured in hazardous locations.

A-2.1.2 Class 0 equipment may have either an enclosure of insulating material which may form a part or the whole of the functional insulation, or a metal enclosure which is separated from live parts by an appropriate insulation.

If equipment with an enclosure of insulating material has provision for protective earthing or internal parts, it is deemed to be of Class I construction.

Class 0 equipment may have parts with double insulation or reinforced insulation, or parts operating at extra-low voltage.

A-2.1.3 Class 0 equipment shall be operated in non-hazardous locations only. The operation in hazardous locations shall be prevented.

A-2.1.4 Protection is obtained:

a) in non-hazardous locations, by functional insulation only; and

b) in hazardous locations, by the prevention of operation by having a plug at the end of the supply cord which does not fit into the installation outlets at hazardous locations.

A-2.1.5 As all electronic measuring apparatus are likely to be used in hazardous locations, Class 0 equipment has been omitted from this standard.

A-2.2 Class I Equipment

A-2.2.1 Class I equipment denotes that, in hazardous locations, protection is assured by connection to a protective conductor.

A-2.2.2 Class I equipment may have some parts with double insulation or reinforced insulation or parts that are supplied with extra-low voltage.

A-2.2.3 Class II equipment may be operated in both non-hazardous and hazardous locations. It will be connected to a protective conductor in the latter case only.

A-2.2.4 Protection is obtained:

a) in non-hazardous locations, by functional insulation; and

b) in hazardous locations, by a plug at the end of the supply cord which establishes a connection to the protective conductor prior to the connection to the supply voltage.

A-2.2.5 The internal connection to the protective earth terminal may be:

a) direct;

b) through a voltage limiting device; and

c) through the tripping coil of a protective switch which disconnects the supply when the voltage or current exceeds a specified value.

A-2.2.6 The protective earth terminal may be connected:

a) to accessible conductive parts; and

b) to a protective screen.

A-2.2.7 According to the installation rules, the protective conductor may be:

a) independently connected to the earth potential;

b) the neutral; and

c) derived from an earth-leakage protecting device.

A-2.3 Class II Equipment

A-2.3.1 Class II equipment denotes inherently safe equipment without provision for protective earthing.

A-2.3.2 The enclosure of insulation-encased equipment may form part or all of the supplementary or reinforced insulation.

If insulation-encased equipment has provision for protective earthing of internal parts, such equipment is regarded as being Class I equipment.

Class II equipment may have parts operating at safety extra-low voltage.

A-2.3.3 Class II equipment may be unconditionally operated both in non-hazardous and hazardous locations.

A-2.3.4 Protection is obtained independently from the installation by the inherent qualities of the equipment.

A-2.4 Class III Equipment

A-2.4.1 Class III equipment denotes that protection is obtained by means of safety extra-low voltage.

A-2.4.2 When extra-low voltage is obtained from a supply mains of higher voltage, a safety transformer or a convertor with separate windings is used.

A-2.4.3 Class III equipment may be operated in non-hazardous, hazardous and extra-hazardous locations.

A-2.4.4 Protection is obtained by functional insulation and by a plug at the end of the supply cord which does not fit into outlets of other than extra-low voltage installations.

APPENDIX B

LIST OF TESTS

Routine tests are marked with an asterisk.

B-1. TESTS TO BE PERFORMED BY INSPECTION

i) Marking, general (**5.1.1**);
ii) Marking by symbols (**5.1.2**);
iii) Identification marking (**5.2**);
iv) Warning symbols (**5.3**);
v) Mains supply marking (**5.4**);
vi) Marking of terminal and operating devices (**5.5**);
vii) Marking of Safety Class II apparatus (**5.6**);
viii) Compartments with voltages exceeding 5 kV (**6.1**);
ix) Preservation of insulation after heating test (**7.3**);
x) Damages after heating test (**7.4**);
xi) Protection against explosion (**9.2**);
xii) Knobs, handles, etc (**9.3.2**);
xiii) Application of wood (**9.3.6**);
xiv) Marking of high-voltage parts (**9.4.2**);
xv) Mechanical requirements on wiring connections, captive screws and interchangeable parts (**9.5.3**);
xvi) Creepage distances and clearances (**9.5.4**);
*xvii) Protective earth connection (**9.5.5**);
xviii) Design of Safety Class II apparatus (**9.5.6**);
xix) Design of Safety Class III apparatus (**9.5.7**);
xx) Identification of terminals (**9.5.9**);
xxi) Design of internal circuits (**9.5.10**);
xxii) Design of mains circuits (**9.6**);
xxiii) Mechanical strength, defects before tests (**11.1**);
xxiv) Components subject to transport stresses (**11.5**);
xxv) Rating and design of resistors and inductors (**13.1**);
xxvi) Rating of capacitors (**13.2**);
xxvii) Protection of motors (**13.3.2**);
xxviii) Brush caps of motors (**13.3.3**);
xxix) Moving parts (**13.3.4**);
xxx) Mains switches (**13.4**);
xxxi) Function of mains switches (**13.4.2**);
xxxii) Breaking capacity of mains switches (**13.4.3**);
xxxiii) Safety switches (**13.5**);
xxxiv) Fusing and interrupting devices (**13.6**);
xxxv) Batteries (**13.7**);
xxxvi) Voltage setting devices (**13.8**);
xxxvii) Screw connections and fixings (**13.9**);

xxxviii) Design of accessible terminals (**15.1.2**);
xxxix) Arrangement of accessible terminals (**15.1.3**);
xl) Earth terminals (**15.2**);
xli) Rating of mains cords (**16.1.2**);
xlii) Rating of other external cords (**16.1.3**);
xliii) Insulation of live conductors (**16.1.4**);
xliv) Plugs of supply cords (**16.1.5**);
xlv) Connection of external cords (**16.2**); and
xlvi) Entries in the instruction manual (**17.2** to **17.4**).

B-2. MEASUREMENTS AND MANUAL TESTS ON THE INOPERATIVE APPARATUS

i) Preservation of marking (**5.1.1**);
ii) Accessible parts (**9.1**);
*iii) Protective earth connection (**9.5.5**);
iv) Combination of protective measures (**9.5.8**);
v) Brush caps (**13.3.3**);
vi) Moving parts (**13.3.4**);
vii) Voltage setting devices (**13.8**);
viii) Screws and rivets connections (**13.9.3**);
ix) Cord bending test (**15.1.1**);
x) Rigidity of terminals (**15.1.2**);
xi) Dimensions of earth terminals [**15.2.1**(d)];
xii) Rigidity of earth terminals [**15.2.1**(h)];
xiii) Connection by earth terminals [**15.2.1**(j)]; and
xiv) Fittings of cords (**16.2.3**).

B-2.1 Creepage Distances and Clearances

i) Basic requirements (**9.5.4**).

B-2.1.1 *Applications*

i) After heating test (**7.3**);
ii) After heating plus mechanical test (**7.4**);
iii) To Safety Class II apparatus (**9.5.6**);
iv) To mains circuits (**9.6**); and
v) After fault conditions tests (**10.2.3**).

B-2.2 Insulation Tests

i) Basic requirements (**9.7**).

B-2.2.1 *Details*

i) Humidity preconditioning (**9.7.1**);
ii) Performance of tests (**9.7.2**);
iii) Insulation resistance tests (**9.7.3**); and
*iv) Voltage tests (**9.7.4**).

B-2.2.2 *Applications*

i) After heating test (**7.3**);
ii) After heating plus mechanical (**7.4**);
iii) On protective screens [**9.5.5**(c)];
iv) After fault conditions tests (**10.2.3**);
v) After mechanical tests (**11.5**); and
vi) On devices for strain and twist relief (**16.2.2**).

B-3. MEASUREMENTS UNDER REFERENCE TEST CONDITIONS

i) Parts directly connected to the supply mains (**2.6.3**);
ii) Parts conductively connected to the supply mains (**2.6.4**);
iii) Reference test conditions (**4.2**);
iv) Power consumption [**5.4**(e)];
v) Ionizing radiation (**6.1**);
vi) Microwave radiation (**6.2**);
vii) Liberation of gases (**6.3**);
viii) Ultrasonic pressure (**6.4**);
ix) Leakage current (**9.8**);
x) Breaking capacity of mains switches (**13.4.3**);
xi) Safety switches (**13.5**); and
xii) Heat developed in cords (**16.1.3**).

B-4. DETERMINATION OF LIVE PARTS

i) Basic requirements (**9.2**).

B-4.1 Applications

i) After heating test (**7.3**);
ii) After heating plus mechanical test (**7.4**);
iii) On operating shafts (**9.3.1**);
iv) On ventilation holes (**9.3.3**);
v) On preset controls (**9.3.4**);
vi) On mains voltage setting devices (**9.3.5**);
vii) On terminals (**9.3.7**)
viii) After removal of covers, etc (**9.4.1**);
ix) Under fault conditions (**10.1**); and
x) After mechanical tests (**11.5**).

B-5. FAULT CONDITIONS TEST

i) Explanation (**4.3**), and
ii) General application (**10**).

B-5.1 Components Subject to the Test

i) Coatings (**10.3.1**);
ii) Current paths (**10.3.2**);
iii) Clearances and creepage distances (**10.3.3**);
iv) Separating components (**10.3.4**);
v) Separating components of Safety Class II apparatus (**10.3.5**);
vi) Fans (**10.3.6**);
vii) Motors (**10.3.7**);
viii) Motors capacitors (**10.3.9**);
ix) Mains transformers (**10.3.10**);
x) Supply apparatus (**10.3.11**); and
xi) Substitute power supply (**10.3.12**).

B-5.2 Consequences to be Checked

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ii) On shock protection (**10.1**);
iii) On heat and fire protection (**10.2**);
iv) Protection by fuses, etc (**10.2.1**);
v) Liberation of flammable gases (**10.2.2**);
vi) On dielectric strength (**10.2.3**);
vii) Operation of thermal cutouts (**13.6.3**); and
viii) On the heating of mains cords (**16.1.3**).

B-6. OTHER TESTS

i) Permissible temperatures (**7.2**);
ii) Heating test (**7.3**);
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iv) Implosion test (**8.1**);
v) Voltage limiting devices (**9.5.5**(b);
vi) Drop test (**11.2**);
vii) Vibration test (**11.3**);
viii) Impact hammer test (**11.4**);
ix) Vicat test (**12**);
x) Tests on motors (**13.3.1**);
xi) Tests on locked motors (**13.3.5**);
xii) Tests on toggle switches and snap-action switches (**13.4.4**);
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